DOCUMENT RESUME

ED 268 978 IR 012 041

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TITLE The Applications of Computers in Education in Developing Countries--with Specific Reference to the Cost-Effectiveness of Computer-Assisted Instruction.
PUB DATE Jun 83
NOTE 140p.; M.Ed. thesis, Queen's University, Kingston, Ontario, Canada. Document contains light type.
PUB TYPE Dissertations/Theses - Master Theses (042) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Cost Effectiveness; *Developing Nations; *Instructional Effectiveness; *Microcomputers; Questionnaires; Secondary Education; Tables (Data); Technological Advancement
IDENTIFIERS *Mexico

ABSTRACT

Designed to examine the application and cost-effectiveness of computer-assisted instruction (CAI) for secondary education in developing countries, this document is divided into eight chapters. A general introduction defines the research problem, describes the research methodology, and provides definitions of key terms used throughout the paper. Chapter 2 discusses the nature of CAI, including its instructional capabilities and its cost-effectiveness. Chapter 3 provides a review of the literature on the effectiveness and costs of a CAI system in the developed countries. A general description of some educational problems in the Third World, with specific reference to educational poverty, is provided in chapter 4, and chapter 5 discusses the applications of computers in the developing countries. This is followed in chapter 6 by cost estimates for a CAI system as used in a Mexican secondary school. A discussion of the appropriateness of CAI in the developing countries comprises chapter 7, while the last chapter summarizes the research project and lists nine conclusions and five recommendations. Selected references, a sample questionnaire and cover letter, a list of computer manufacturers, and the categorization of selected developing countries by level of computer activity are provided. (JB)

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THE APPLICATIONS OF COMPUTERS IN EDUCATION IN DEVELOPING COUNTRIES --- WITH SPECIFIC REFERENCE TO THE COST-EFFECTIVENESS OF COMPUTER-ASSISTED INSTRUCTION

by

Kwok-Wing Lai

A Project submitted to the
Faculty of Education
in partial fulfillment of the requirements
for the degree of Master of Education

Queen's University
Kingston, Ontario, Canada
June, 1983

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ABSTRACT

The purpose of this project is to examine the applications of computers in education in the developing countries in general, and the cost-effectiveness of using computer-assisted instruction in secondary education in particular.

The effectiveness of CAI as a method of instruction and the cost structure of a CAI system using microcomputers as the delivery device in a Mexican high school are discussed. The cost of CAI is estimated and its cost-effectiveness and feasibility evaluated. The appropriateness of this new technology to the Third World is also examined. It is found that CAI is not cost-effective or feasible for Mexican high schools and its appropriateness to the Third world countries is also doubted.

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to Dr. D. H. Crawford, my project advisor, for his immeasurable assistance throughout the course of study. His subtle comments saved the writer from many errors.

I would also like to thank Dr. J. D. Burnett and Dr. W.C. Higginson for their helpful comments.

My thanks also go to the following computer manufacturers which provided useful information to this study:

Control Data Corporation

Educational Computer Corporation

Heath/Zenith Inc.

International Business Machines Inc.

N C R Corporation

National Semiconductor Inc.

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CHAPTER 1

INTRODUCTION

1.1 The Problem

Since the first computer-assisted instruction system was programmed and the first known CAI experiment conducted by three IBM researchers in New York in 1958 (Matovich,1973), the computer has been used as a means of instruction in education. Recent technological breakthroughs in computers, especially in the development of microcomputers, not only reduce the costs but expand the capability and flexibility of computers with respect to instructional applications (Toong & Gupta, 1982). A recent study points out that the cost of computer logic devices is falling at a rate of 25% per year and the cost of computer memory at the rate of 40% per year. While computational speed has increased by a factor of 200 in 25 years, in the same period, the cost, the energy consumption and the size of computers of comparable power have decreased by a factor of 10,000 (Toong & Gupta,1982). With this huge reduction in price, it is not surprising to see that computers, or CAI are being used increasingly in all levels of education providing individualised instruction to students in practically every subject area, and that their use has been

documented as effective (Thomas,1979; Edwards et al, 1974,1975). According to one study (Thomas, 1979), it is predicted that during the 1980s the majority of secondary schools in the U.S.A. will use computers for some instructional purposes.

In view of this huge reduction in computer cost and its increasing use in the developed countries, one wonders whether computers can be used effectively in education in the Third World. As documented by some studies (Jamison & Leslie, 1980; Arnove,1976), educational technologies like TV and radio have been successfully implemented in the developing countries to help alleviate certain educational problems. One of them is the continued rise of educational costs. The purposes of this project is thus to examine whether CAI as a new technology which is delivered by microcomputers can help to reduce the educational costs of the Third World so that the quantity and quality of education in these countries may be improved. More specifically, the cost-effectiveness of the CAI system, relative to the traditional method of instruction will be examined in secondary education in Mexico. As this problem is so complex, and hard data are not readily available to the writer, this study can only be treated as a preliminary one and further researches on this area will have to be conducted in future.

1.2 Need and Scope of the Study

Although the use of computer technology in the

Third World has been examined (U.N.,1973), its application in the educational field is not yet widely documented. As findings on both the effectiveness and costs of CAI system in the developed countries are so encouraging, as can be seen from some recent studies , e.g. Kerr,1977; Thomas,1979; Levin & Woo, 1980, there is a need to examine whether it is also cost-effective in the developing countries so that data can be available to policy makers of these countries before any decisions with regard to the use of this new technology in totally different social, economical, political and cultural settings are made.

Due to the limitations of the writer's resources--in terms of time and availability of data, the scope of this study is necessarily limited. In this paper only computer-assisted instruction will be discussed, without examining all other types of computer applications in education,e.g. computer-managed instruction. Also, the study will focus on the use of CAI in secondary education, mainly because of the writer's own experience as a high school teacher. No empirical study was carried out but the cost-effectiveness of CAI is examined using a hypothetical case based on data drawn from Mexico.

1.3 Methodology of the Study

The focus of this study is on the cost-effectiveness of the application of CAI in the developing countries. Due to the nature of this project, no empirical research has been conducted. The following

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methods were used:

(1) Relevant literature were gathered and reviewed.

(2) A questionnaire was designed and sent to 24 computer manufacturers in the U.S.A. to solicit information on their sales of computer software and hardware to the developing countries for educational purposes.

(3) Personal interviews were conducted, the interviewees being teachers of selected Third world countries and researchers of organisations who monitor developmental problems of these countries (e.g. The International Development Research Centre in Ottawa, Canada).

(4) Using data obtained from (1) to (3), cost components of a CAI system, utilising the microcomputer as the delivery device in a hypothetical Mexican secondary school were estimated. Its cost-effectiveness, compared to the traditional instructional method was then evaluated. Its cost feasibility was also examined.

1.4 Definition of Terms

There are some key terms in this paper that have to defined first. They are : computer; computer-assisted instruction; and developing countries.

1.4.1 Computer

In this project computer is defined as a device that "accepts data, performs operations on that data in a sequence decided by a program and outputs the result" (Ruggles et al, 1982,pp.64-65).

1.4.2 CAI and Its Modes

In the literature that the writer has surveyed, CAI is defined differently by different writers mainly due to different purposes. Basically they can be grouped as a broader or narrower definition of CAI.

In the broader sense, CAI is defined as the direct use of the computer (large-scale computing system, mini- or micro-computer) for the facilitation of learning -- i.e. the computer is used to make learning easier and more likely to occur (Burke,1982,p.16). According to this definition, there are at least four modes of CAI (Matovich,1973; Coburn et al,1982):

(1) Drill & Practice

The most common and best known application of CAI is drill and practice. In this mode students are assigned by teachers to use the CAI programs for drill and practice in developing particular sets of discrete skills in mathematics, reading, spelling or other basic skill areas.

(2) Tutorial

In this CAI mode, the computer instructs the student in some areas of knowledge in somewhat the same way as a teacher would in a one-to-one situation. Most tutorial programs resemble Socratic dialogues.

(3) Simulation/Games

In this mode, the CAI program imitates a real or imaginary system based on the modeller's theory of the operation of that system. Students are thus given opportunities to play life-like roles and to take part in the decision making process in realistic settings.

(4) Problem Solving

In this mode, students generate their own problems through the computer and provide their own answers with the aids of the computer.

For the narrower definition, CAI is defined as such only when the computer presents the materials, guides, directs and tests the student throughout the learning process. Based on this definition, only drill and practice, which is designed to assist the student in maintaining and mastering a skill, and tutorial, which is designed to assist the student in acquiring a skill would be included (Matovich,1973; Doerr,1979).

From the survey of literature, it seems that most of the writers use CAI in the broader sense and in this project CAI will be taken to refer to the broader definition which includes the four modes of instruction that we have just discussed.

1.4.3 Developing Country

When we talk about developing countris, we refer to about one hundred nations which are poor in money income. According to a recent UNESCO report (1981), developing

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countries include all countries in Central and South America, Africa (except South Africa), Asia (except Japan and the Asian republics of U.S.S.R.) and lands in the Pacific Ocean (except Australia and New Zealand). The average annual per capita income of these countries ranges from U.S.$100 to $600, but the most typical is about $100.

These countries are characteristered by the predominance of an agricultural sector and the underdevelopment of the manufacturing and service industries, high population growth rate, high illiteracy rate and at least 20% of the economically active male population are unemployed, and a much higher percentage underemployed. On the whole, the developing countries lag far behind in all aspects of social and economic development than the developed ones. In this paper, developing countries, developing nations and Third World are used interchangably.

1.5 Organisation of this Paper

This project is divided into eight chapters. In the following chapter a framework of whether CAI should be used in secondary schools is discussed. Chapter three is a review of literature on the cost-effectiveness of CAI in the developed countries. A general description of some educational problems in the Third World, with specific reference to educational poverty will be attempted in the following chapter. In chapter five the applications of computers in the developing countries will be discussed;

this is followed by a cost estimation of a CAI system as used in a Mexican secondary school in chapter six. A discussion of the appropriateness of CAI in the developing countries comprises chapter seven, while the last chapter summarizes the whole project and draws conclusions. A few recommendations are then made.

CHAPTER 2

SHOULD CAI BE USED IN SCHOOLS?

A FRAMEWORK FOR DISCUSSION

2.1 Introduction

During the past ten years, different CAI modes (drill and practice, tutorial, simulation and problem solving) have increasingly been used in education in the developed countries . However, the increasing use of computer doesn't mean that it can be justified on economic or instructional grounds. Also, it does not imply that CAI can be used effectively by teachers. Disappointed by the misuse of computers, Papert & Solomon (1972) wrote," How strange, then, that computers in education should so often reduce to using bright new gadgets to teach the same old stuff in thinly disguised versions of the same old way." In view of this, I would like to discuss briefly why and in what circumstances CAI should or should not be used in schools. A framework for examining the use of computers in education is discussed here before a literature review of the cost-effectiveness of CAI is attempted in the next chapter.

In discussing whether computers should be used in education, Milner & Wildberger (1977) suggest that we should examine the following three factors:

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(a) Whether the use of computer for instruction is essential and there is no other competitive method for accomplishing the same results.

(b) Whether the computer has certain unique characteristics which can provide important instructional capabilities and

(c) Whether the computer is simply the most economical way to perform instruction which may be done equally well by other methods.

Only after we have carefully evaluated these three factors can a decision on whether CAI should be used in schools can be made. The following three sections discuss these three factors in more detail while in the next chapter empirical research findings will be reviewed which provide concrete support as to whether CAI should be adopted.

2.2 Factor One: Is CAI Essential for Instruction?

There is no doubt that the computer is essential to education in certain areas of studies. When the computer itself is a subject of study (e.g. the development of autonatel system, programming language, etc.) or when it is usel as a tool (e.g. for the manuipulation of large amount of data in statistical analysis), as suggested by Taylor (1980), the use of the computer is essential and there is really no other substitutes.

The simulation node of CAI, i.e. the simulation of reality is also unique to CAI and has so far no other substitutes. Such a simulation is essential if we are

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to instruct students about a real system or about real world phenomena which are unavailable by other means, e.g. the training of pilots or nuclear power operators. Also, computer simulation of science experiments can provide learning experiences that might not otherwise be available because of such factors as safety, equipment cost or availability, prohibitive set-up time or simply inconvenience (Milner & Wildberger,1977).

2.3 Factor Two: Does CAI have Unique Instructional Capabilitis?

Computers may be essential for learning a certain skills and in certain levels of education. However, at the secondary level, it may not be essential. Although not essential, it provides yet certain unique and intangible benefits to instruction which can not be provided by other methods of instruction (Hickey,1968; Carnegie Commission on Higher Education,1972; Matovich,1973; Milner & Wildberger,1977; Rahmlow,1978; Doerr,1979).

The single most powerful reason for the use of computer in the instructional process is its potential to individualise learning. Individualising is made possible because of the one-to-one interaction between the computer and the student. Because of this, subject matter and the level of difficulty can be tailored to the unique learning needs of individual learners. Also, since the school administration is not constrainted by a lack of instructors, and courseware is commercially available or can be written

by teachers, CAI offers a richer variety of courses for students to choose. Each student therefore can follow a course of study at the pace indicated by his own ability. This can eliminate the common classroom phenomeon where the slower students cannot catch up while the faster students have to wait and waste their time doing nothing in the classroom.

According to Milner & Wildberger (1977), an important characteristics of any individualised instructional system is its responsiveness. Due to the flexibility in instructional procedure, the CAI can have complex multi-level branching to remedial or advanced instruction based on student's performance, which is only made possible by the use of computers. Also, when working with the computer, student has the sensation of full attention from a tutor which is never impatient and never fails to answer him.

Another unique benefit of CAI is that it may permit students to act as teachers and as explorers of knowledge, especially in the problem solving mode of CAI instruction. In this mode, students can use their own ways to tackle problems they have generated for themselves and with methodologies that they invent for themselves. For example, problem solving by using the Logo programming language may encourage students to think, create and express their own ideas (Papert,1980). According to Milner & Wildberger (1977), computing is a unique means for the expression of

ideas because it provides immediate feedback of problem solving efforts, a precise language expressing problem solving processes and new forms of expressions for old and new ideas.

Geographic flexibility of CAI is also a benefit to students since they can learn at remote locations. With the large computing systems, students can also have access to experts through the systems that they could not normally interact with previously. Also, validated materials produced by master teachers can be available to students which may then improve the quality of instruction (Rahmlow,1978).

The unique capabilities of CAI that we have just discussed all provide benefits to students. As for teachers, there are also some advantages. By assigning students to computer terminals where they can have drill and practice or tutorial lessons, a great deal of trouble of repetition for the teacher is taken away. Also, there is more time for teacher-student contact. The text-editing capabilities of the computer also allow the teacher to revise and update the instructional materials relatively easily, thus encouraging frequent changes of actual materials used for instruction. Also related to instruction is the record keeping capability of certain computers which allows teachers to keep track of the progress of their students so that remedial or advanced instruction can be provided for them (Rahmlow,1978).

Although CAI has all these instructional

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capabilities, one has to be reminded that there are some limitations to using it in education.

It is argued by Rahmlow (1978) that students may have a feeling of isolation when they have to work with the terminals alone. If the educational objective of the school/educational system is to enhance students' inter-personal relationship on a face-to-face basis, individualised computer-based education would not be a good method of instruction.

Another limitation of using computer in instruction, which is really not unique to it, is the problem of malfunction. The breakdown either of the system, or the communication links between the computer and the terminals can be very frustrating and repair very time consuming. However, this inconvenience will be minimised when microcomputers are used to deliver the CAI since they are all stand alone computers; a breakdown of one will not affect the others.

Finally, CAI programs are not easy to write. A period of training is required before one can write a CAI program. The production of sophisticated CAI materials requires expertise in the subject matter and computer programming, or else the computer will simply become an electronic 'page-turner' only. It is argued by Austin (1975) that CAI is still so difficult to market not only because the hardware and software must be tested, but because the courseware must be combined in such a way as to

achieve a thoroughly dependable and effective 'teaching system', not just a 'computing system' (p.475).

On balance, the limitations of CAI are far out-weighed by the benefits, which are really unique to the computer. We will provide some empirical evidence on the benefits of CAI in the learning process in the next chapter.

2.4 Factor Three: Is CAI Cost-Effective?

Even if CAI is essential in the learning of certain skills, or it provides certain unique benefits to instruction in secondary education, we still have to examine its cost-effectiveness before deciding whether to use it or not. Cost effectiveness is a relative term. When we measure the cost-effectiveness of the CAI, we have to measure the change in its desired output (e.g. in terms of achievement, enrolment,etc.) and its cost and compare this with the same variables of other methods of instructions -- be it traditional, TV, radio,etc.(Carnoy,1976). Expressed as an equation, the comparison could be written as:

$$\frac{\text{Output (CAI)}}{\text{Cost (CAI)}} > \frac{\text{Output (Other Method of Instruction)}}{\text{Cost (Other Method of Instruction)}}$$

Whether CAI could be adopted on economic grounds depends on the cost/output ratios of these two methods of instruction. If the CAI ratio is greater, it could be adopted.

From this equation we can see that not only the

effectiveness of the methods of instructions have to be measured, which is in fact very difficult to quantify, but the costs of the methods have to be calculated. In this paper, instead of trying to quantify the effectiveness of each method of instruction, we try only to examine whether CAI is more or is less effective than the traditional method of instruction and pay more attention to the computation of the cost of a CAI system. In this section, we would like to outline the most important factors that we have to consider in measuring the cost of a CAI system. A detailed breakdown and computation of the system will be found in chapter six.

As suggested by Austin (1975) and Kearsley (1977), when we try to examine the cost of a CAI system, the following factors have to be considered:

(1) Firstly we have to consider the type of CAI system involved because different type of CAI system will have different cost components. At present there are three types of CAI systems:

(a) The first one is the large scale computing system. There is a time shared CPU (Central Processing Unit) with a large number of remotely located terminals. It is like a utility in that all computers and systems programming operations are managed at a central facility and both the students and instructors see only the terminals.

(b) The second one is the time-shared minicomputer system serving only a small number of local terminals. The

instructional materials and courseware are therefore mainly locally produced.

(c) The last one is the stand alone mini- or micro-computer (processor) serving a single student at a time.

(2) Besides the types of computer systems used, we also have to examine the types and levels of students that the CAI system is going to serve. The types of students may include professionals like lawyers or doctors who have to upgrade their skills and update their knowledge; adult learners for vocational training or disadvantaged students like deaf, blind or mentally retarded. The levels of education may range from elementary to adult education.

(3) The third factor that we have to consider is the type of instruction that the CAI system provides. In other words, whether the CAI is used for mainline or adjunct instructions. As mainline instruction, the CAI replaces the existing method of instruction and therefore represents a replacement cost. But as adjunct instruction, it only serves as supplement or enrichment purposes where the cost represents an add-on cost. Thus the costs of the CAI will vary, depending on the type of instruction.

(4) The instructional quality and complexity of the CAI will also affect costs. Courses which involve extensive audio or graphic components, remedial or enrichment sequences, alternative levels of difficulty or student control features will require more programming or process

time and therefore will affect the cost. Thus, we have to take the mode of instruction into consideration when we examine the cost. Generally speaking, CAI programs of drill and practice and tutorial need less programming time than simulation or problem solving modes and therefore are less costly.

(5) Finally, the number of students using the CAI programs is also a factor that one has to consider in examining the cost structure of a CAI system. If sufficiently large number of students use the same program, then economies of scale may result.

The above five factors are only general guidelines used to evaluate the costs of a CAI system. Detailed cost breakdowns and the computation of cost components of CAI will be attempted in Chapter six while some empirical studies on the cost-effectiveness of CAI in the developed countries will be reviewed in the following chapter.

2.5 Summary

In this chapter I have tried to provide a framework which may facilitate the discussion of the application of computer in education. Before deciding whether CAI should be used in schools, we have to consider three factors. These factors are (1) whether is is essential to use CAI for instruction ,(2) whether CAI is unique and effective for the subject areas under our consideration and (3) whether it is cost-effectiveness. Only with a clear understanding of the first two factors will the computer not be misused in

schools. An examination of the third one would provide us with an idea of whether CAI can be justified on economic grounds, which is crucial, especially for those countries which are lack of funds.

CHAPTER 3

REVIEW OF LITERATURE

3.1 Introduction

In the last chapter we pointed out that we had to examine the effectiveness and the costs of a CAI system before deciding whether it could be used in schools. In this chapter empirical studies relating to these two areas are reviewed.

3.2 Methodology of Review of Literature

In the survey of related literature, two areas were identified. One was the effectiveness of CAI, in terms of students' achievement and reduction of learning time and the other one was cost. An ERIC computer search was carried out in September 1982 on the application of computers in education in the Third World. Only three articles were identified, but none of these had any specific reference to the cost-effectiveness of CAI. An IDRC (International Development Research Centre) computer search (on UNESCO and BIBLIOL files) was carried out in January 1983 in Ottawa but the result was also very disappointing. The writer therefore has to conclude that either no empirical research has been conducted in this area or the research findings are not published and therefore are not available to the writer.

Since no relevant reports focusing on the

developing nations were identified, what follows is only a review of the cost-effectiveness of CAI in secondary education in developed countries only. The identification of relevant literature was pursued in the following ways:

(a) Two ERIC indices--CIJE (Current Index to Journals in Education) and RIE (Resource in Education Index) between 1978 and 1983 were searched and all relevant articles were identified.

(b) A number of journals which normally contain research or articles related to computer in education,e.g. The AEDS Journal, Educational Technology in the past five years were completely reviewed.

(c) A number of studies which reviewed research findings on these two areas were identified. Some of the research studies quoted in these review articles were further reviewed by the writer. The present review of the effectiveness of CAI summarizes the findings from the following review articles: Hickey,1968; Suppes & Morningstar,1969; Matovich,1973; Edwards, Norton, Taylor, Van Dusseldorp & Weiss, 1974, 1975; McDougall,1975; Stakenas & Kaufman,1977; Thomas,1979; and Dence,1980.

(d) As for the costs of CAI, only those studies which are relevant to the present study are reviewed here.

3.3 Effectiveness of CAI

3.3.1 Achievements

3.3.1.1 CAI as Supplementary Instruction

Studies on the effectiveness of CAI, in terms of

students' achievements in secondary education prior to 1970 were reviewed by Suppes & Morningstar (1969) and subsequent reviews of research were carried out by Jamison, Suppes & Wells (1974), Edwards, Norton, Taylor, Weiss & Van Dusseldorp (1975) and Thomas (1979). Most of these studies showed that students exposed to supplementary instruction through CAI performed at a higher level than those students not so exposed. Table 1 summarises these findings from 1972 to 1981.

As shown in Table 1, the data on achievement was very encouraging. Of the total 14 studies reviewed, the majority showed that students receiving CAI achieved more than non-CAI students. In some cases, the results were quite remarkable. For example, in a research conducted by Broderick(1973) in London, the performance of students taught Biology by a teacher using CAI was compared with that of students taught by the same teacher without the aid of CAI. 440 students from seven secondary and grammar schools participated in this study which lasted for seven weeks. Pretest and posttest were administered. It was found that CAI students of all ability levels gained higher scores on the posttest than comparable non-CAI students. For example, the average gain for girls of the CAI groups was 13.97 points in the raw score while the non-CAI girls only gained 6.88 points. The gain of the CAI group was statistically significant.

In other subject areas and for different groups of

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Table 1: Studies that involved CAI as a Supplement to Traditional Instruction in Secondary Education, 1972-81

Study	Year	Mode	Subject	Result*
Dunn	1972	Tutorial D & P	Algebra	+
Taylor, Hansen & Brown	1972	D & P	Math	+
Broderick	1973 1974	Tutorial	Biology	+
Fitzerald	1974	Tutorial	Reading	=
Johnson	1974	Tutorial	Math	=
Hughes	1974	Simulation	Physics	+
Morgan & Richardson	1974	D & P	Algebra	+
Bukoski & Korotkin	1975	D & P	Math	+
Fricke	1976	D & P	Math., Reading	+
Wolcott	1976	Tutorial	Typing	-
Toggenburgh & McDaniel	1977	D & P	Math., Reading Language arts	-
Miller & Randolph	1977	Simulation	Careers	+
Wright	1977	D & P	Math	+
Poore et al	1981	Tutorial D & P	Basic Skill Math	+

Note: * a "+" sign indicates that the students receiving CAI achieved more than non-CAI students. A "-" sign indicates that the students involved in CAI did less well, while an "=" sign indicates the same level of achievement.

learners, the effectiveness of the CAI was also documented. Fricke (1975) used the Computer Curriculum Corporation's drill and practice programs in Mathematics and Reading in a school of the deaf in Pensylvania in 1975. The CCC is an outgrowth of work done at the Stanford University in the mid-60s where programs in the areas of mathematics, reading and the language arts are being developed. With an average spending of 1.7 hours per week for a school year (175 days), the middle school students achieved an average 1.3 and 0.4 grade level gains in Mathematics and Reading, respectively. High school students showed a 1.1 grade level gain in Mathematics and a 1.3 average grade level gain in Reading.

In another study (Miller & Randolph, 1977) sixty nine-grade students in a junior high school in Missouri participated in a study designed to investigate the effectiveness and feasibility of the utilisation of a computer-based simulation approach in the presentation of occupational information. Compared with the non-simulation treatment, the mean scores for the group which experienced the CAI simulation lessons were significantly higher on cognitive achievement and occupational awareness (at 0.05 significant level).

CAI is also effective in remediation. In the study conducted by Poore et al.(1981), the PLATO Basic Skills Mathematics Lessons were used in three high schools in Florida for remediation. The PLATO is an instructional

curriculum developed by the Control data Corporation to enable functionally illiterates to achieve eighth-grade level of competence in reading, mathematics and language skills. A total of 236 grades 10-12 students who failed in the Florida Statewide Assessment Test were chosen to participate in this study. Pretest and posttest were administered, using the Level II (Form A) of the Adult Basic Learning Exam to determine the gains from these CAI programs. After spending an average of 20 hours in the CAI-mathematics lessons, the gain of the median scores for all students was 1.5 grade equivalents. For students completing the entire curriculum, i.e., after spending 22 hours in the mathematics lessons, they gained 2.4 grade equivalents. The result was quite remarkable.

From these studies, we can see that in general, CAI is at least as, if not more effective than the traditional method of instruction when it is used as a supplement.

3.3.1.2 CAI as a Substitute for Traditional Instruction

Fewer studies were conducted to examine whether CAI is as effective as the traditional method of instruction when it is used as a substitute. The results obtained were inconclusive. Although as can be seen from Table 2, which summarises studies that involved CAI as a substitute for traditional instruction from 1966 to 1974, CAI was as effective as traditional instruction in the secondary level, at other levels of education, i.e., at elementary and

Table 2: Studies that invloved CAI as a Substitute for Traditional Instruction,1966-74

Study	Year	Mode	Subject	Result
Johnson	1966	Problem Solving	Math	=
Diamond	1969	Mixed	Biology,Reading	+
Cole	1971	D & P	General Math	+
Katz	1971	Problem Solving	Math	+,-
Morgan	1972	Tutorial	Algebra	+
Lunetta	1973	Simulation	Physics	+
Hughes	1974	Simulation	Physics	-

college levels, the results were less positive (Edward et al., 1975; Thomas, 1979).

A study was conducted in four Philadelphia high schools by Diamond in 1969. In this study CAI in Biology and Developmental Reading was administered. The achievement of the CAI students was compared with students in traditionally instructed classes by using standardised tests. it was found out that in reading, the CAI classes performed significantly better (at 0.01 level) than the non-CAI classes. However, there was no significant difference between these two groups in biology. This was attributed to computer down-time and a lack of sufficient content validity in the standardised biology test. The difference in achievement between the CAI and non-CAI students was not attributed to the difference in ability or in teacher effectiveness since these two factors were controlled.

In a project called REFLECT developed by the Montgomery County Public Schools System in Maryland, U.S.A., the effectiveness of CAI as a substitute to traditional instruction was studied (Morgan & Richardson, 1972). In this semester-long study, it was reported that students using the algebra CAI tutorial program for remediation, without the assistance of the teacher, achieved significantly higher scores on standardised tests than those non-CAI students.

Lunetta & Blick(1973) compared the effectiveness of

CAI simulation in teaching force and motion in physics with traditional methods where students interacted with their teachers and with real laboratory materials or film loops. 146 students with similar academic and socio-economic backgrounds were chosen from five public high schools in Massachusetts and Connecticut. The CAI students spent 1 hour and 40 minutes at the computer terminals while the non-CAI students spent 6 to 11 fifty-minute periods in the unit, approximately 8.3 times as long in instruction time as the CAI group. Pretest and posttest with multi-choice items were administered. An analysis of variance (ANOVA) was conducted on the pretest-posttest scores for these groups. It was found out that learning was significantly greater for students studying the concepts through computer simulation dialogs than the other groups.

Besides the studies that we have just reviewed, many educators support the application of the CAI in education because of its effectiveness. For example, Jamison et al.(1974, p.55) concluded after comparing the effectiveness of CAI, programmed instruction and television with traditional instruction that" CAI is about as effective as TI [traditional instruction] when used as a replacement..." Thomas (1979, p.106), after reviewing studies between 1974-1979, also concluded that " at the secondary level the students have shown higher achievement scores whether measured by teacher-made tests, or on predicted versus actual scores using regression analysis

methods." Other studies and reviews also conclude that CAI in secondary level is as equal or better than traditional method, in terms of student achievement. These studies include Fletcher, Suppes & Jamison (1972), Roberts (1976), and Dunkin (1977).

3.3.2 Reduction of Time for Learning

From the reviews of literature that were undertaken by Edwards et al (1974,1975) and Thomas (1979), it was clear that CAI study reduced the time required for a student to complete a unit of study. According to Thomas (1979), this is likely to be true since in the traditional method of instruction, students have to spend a higher percentage of 'clock' time actually attendng to learning, waiting to be called on, and reviewing aleady learned material in a group setting. The studies reviewed by Edwards et al and Thomas are summarised in Table 3.

3.4 Cost of CAI

So far from what we have reviewed, it seems that CAI is effective in terms of higher achievement and a shorter learning time for students. In this section, we would like to review studies relating to the costs of CAI, to see whether it is economical to use it in classrooms in high schools. A discussion of costs for computer applications in education is complex due to the fact that a variety of factors have to be taken into account which are not yet agreed upon by researchers. One example is the computation of average cost of CAI, a useful variable in examining the

Table 3: Time required for Students to Learn through CAI compared with Traditional Method of Instruction in Secondary School,1973-77

Study	Year	Subject	Result*
Lunetta	1973	Physics	-
Hughes	1974	Program for the Deaf	=
Solomon	1974	Accounting	-
Goodson	1975	Math	-
Wolcott	1976	Typing	-
Bachor	1976	Math	-
Diedrick & Thomas	1977	Ignition Problems	-

Note :* an "-" sign indicates less time was required by CAI students, while an "=" sign indicates the same time required by both CAI and non-CAI students.

cost-effectiveness of CAI. So far the computation of the average cost, say, the cost per student contact hour, is not based on a common formula. Some course components, e.g. the development of courseware, the management of the computing room, etc. may or may not be included in the calculation of costs in these studies. Thus, we have to be very careful in examining the results of these studies. There are some review articles on the costs of CAI which may be of interest to the reader. They are: Jamison, Suppes & Butler,1970; Jamison, Suppes & Wells,1974; Stakenas & Kaufman,1977 and Thomas,1979.

Some of the studies reviewed by the writer only examined the costs of CAI, without comparing it with the costs of traditional method of instruction. Due to the difference in the computation of costs, these data may not be compatible. For example, Fricke (1976) reported that the cost per student contact hour was estimated to be $3.80, when CAI programs on reading, mathematics and language arts were used. But using similar materials (which were also produced by Computer Curriculum Corporation), Atkinson (1974) estimated the cost at only $0.55 per day.

There were some studies which compared the costs of CAI with traditional method of instruction. After reviewing some studies (Allen,1973; Morgan,1969; and Watson,1972) on this area, Stakenas & Kaufman (1975) stated that CAI was not considered to be competitive. Seltzer (1971, quoted from

Stakenas & Kaufman,1975) also reported that the only potential for the CAI to be cost-effectiveness was in higher education. It was also reported by Butman (1973) that CAI would only be cost-effectiveness in some high cost areas, for example, in special education or professional development programmes.

However, all these studies were carried out at least ten years ago. In view of the drastic reduction in the costs of computer hardware and software in recent years, these research findings may not be valid now. For example, Fricke (1976) showed that the total cost of a CAI system projected for five years in a high school for the deaf in Pennsylvania was estimated to be at U.S.$180,000. Based on the first year's average of 1.7 hour of use per student per week, the average cost per student hour was $3.80. It was considered to be cost-effective compared to traditional instruction since the salaries of teacher aide in the State were $5.08 per hour in 1975.

With the increasing number of students using CAI in schools, the cost can be greatly reduced. Kearsley (1977) compared the cost of PLATO and TICCIT systems and found that they were $0.34 -$0.68 and $0.36 per student contact hour, respectively. The computation was based on the assumption that there were 4,000 terminals, in operation time of 2,000 hours per week and a 5-year life expectancy of the computer hardware. If the number of users increased to 500, then the cost would increase by a factor of 8.

A study conducted by Stanford University in 1977-78 on the effectiveness of CAI for culturally disadvantaged children in the Los Angeles School District showed that CAI was a cost feasible technology in that school district. With an annual total cost of $136 per student for a daily session of 10 minutes, the cost was within the budget limit set by the U.S. government (Levin & Woo,1980).

All the above mentioned studies focused on minicomputer or large-scale computing system as the delivery system of CAI in schools. What we are more interested is the cost-effectiveness of the microcomputer. A recent study (Kester,1982) showed that the use of microcomputer assisted basic skills instruction was economically viable for students of a community college in a depressed area in the U.S.A. The study examined the relative costs of computer-assisted and regular faculty instruction in basic skills. The conclusion was that over a 5 year period, significant savings could be made through the use of CAI.

The potential for a cost-effective micro-computer-assisted instruction system was mentioned in other studies. In a less well-documented study, Doerr (1979) stated that instructional computing using microcomputers could be delivered for roughly U.S.$0.18 per student hour, based on six hours of use per day through a 180 day school year for an estimated five year useful life of the hardware.

Although up to now whether CAI is cost effective is

still a very controversial issue in the educational field, many developed countries, besides U.S.A., have already made the move of promoting its use in secondary and elementary schools, especially with microcomputers. It seems that the reason is sometimes more a political than an educational or economical one (Kearsley,1977). According to Bras (1980, as quoted from Ruggles et al,1982), there is a project in France entitled "The 10,000 Microcomputer Experiment" in which all Lycees in France will be equipped with microcomputers by 1986. In Canada, certain provinces are establishing major programmes for the use of microcomputers in the classrooms. For example, the Education Department of Alberta has plans to order a minimum of 1,000 microcomputers while a recent survey by TV Ontario shows that there are already 4,300 microcomputers in the school system. TV Ontario is also planning to organise microcomputer workshops so that 10,000 educators (approximately 10% of the teaching force) in Ontario can participate to learn how to use microconputers in the classroons (Ruggles et al,1982). As more and more developed countries use microcomputers in education, the costs of hardware and software will further be reduced. Actually, even nowadays, the cost of a microcomputer is more or less the same as a color TV, a cost that can hardly be described as too expensive in the developed countries.

3.5 Summary

In this chapter we have reviewed a number of

studies relating to the cost and effectiveness of CAI as a means of instruction. We found that there is ample empirical support for the effectiveness of CAI, in terms of higher achievements for students receiving CAI and a reduction of learning time. With regard to cost, since there is still much confusion in the methodologies of cost computing, the research findings reviewed were highly case-specific and no general conclusion can be drawn. However, it is evident that the cost of CAI is declining and there is a great potential for its use in secondary schools, at least in developed countries.

CHAPTER 4

EDUCATIONAL PROBLEMS IN THE THIRD WORLD

4.1 Introduction

The underdevelopment of the educational system in the Third world has been documented in many studies (Buchanan,1975; Phillips,1975). One of the educational problems that deserves our special attention is the large scale educational poverty found at the primary and secondary levels of education which is causing an increasing number of adult illiterates in the Third World in the 1980s. This problem is partly due to the economic poverty of these countries and partly to the rising educational costs especially in the past ten years. Since recent studies (Jamison & Leslie,1980; Carnoy,1976) have documented that the use of some educational technologies like TV and radio can help to reduce educational costs, we would like to see whether the use of CAI in these countries can have similar effect. Before we discuss the cost-effectiveness of CAI in chapter six, a brief discussion of a few related educational problems in the developing counries may provide us a better understanding of these problems and the context in which CAI may be used.

4.2 The Problem of Illiteracy

The educational poverty of the Third World is

reflected in the increasing number of illiterates in these countries. Before we examine the problem of illiteracy in the Third world, we have to make clear what being an illiterate person means. Different countries have different definitions of illiteracy. In some developing countries, a person who cannot read the letters of the alphabet may be called illiterate, but in the developed countries, anyone who is" incapable of completeing a complicated questionnaire or of assimilating written instructions containing technical language " is regarded as a functional illiterate (Lestage,1982,p.5). In this paper we will adopt the recent UNESCO (1979) definition which defines that a person is functionally illiterate " who cannot engage in all those activities in which literacy is required for effective functioning of his group and community and also for enabling him to continue to use reading, writing and calculation for his own and the community's development." (p.18)

The problem of illiteracy continues to be a serious problem in the Third World in the 1980s. According to the UNESCO (1982), the adult illiterates (defined as 15 years old and above) in developing countries accounted for 41.2% of the adult population in 1980, whereas in the developed countries only 2.1% of their population were illiterate, as can be seen from Table 4. From this table we can also see that the problem of illiteracy is most serious in Africa.

According to the same report published by the UNESCO in 1982,the developed countries have

Table 4: Illiterates aged 15 and above in the World,1980

Region	Population (aged 15 and above,in m.)	% of Illiterate
World	2,818	28.9
Developed	888	2.1
Developing	1,930	41.2
Africa		70.6
Asia		43.6
Latin America		28.1

source: Lestage,1982

practically solved all the problems of schooling at the primary level (first level), and so illiteracy in these countries has virtually disappeared in the age group 15-19. But for the developing countries, illiteracy will still last for a long time because it is only in the last 30 years, or even since their independence after the second world war that compulsory primary education has been actually insisted upon. Indeed, according to a report (Phillips,1975) submitted to the 1974 World Population Conference, it was estimated that by 1985 the developing regions would only be slightly nearer to universal education for children aged 6 to 11 than they were in 1970. In order to have universal education by 1985, these countries would have to treble the average annual enrolment increase attained during the 1960s, which is obviously impossible. Thus, it is estimated that by the end of this century the absolute number of illiterates in the world will be 76 million (excluding China, the Democratic People's Republic of Korea and the Socialist Republic of Vietnam) with the overwhelming majority in the Third World, although its illiteracy rate will drop from 30.9% in 1980 to 19.0% in the year 2000 (Lestage,1982).

4.3 The Problem of Enrolment

The increasing number of illiterate persons in the Third World is partly a legacy of the colonial era and partly due to the stagnation of the enrolment ratios in the primary level of education. Recent data showed that the enrolment

ratios of all levels of education in the Third World were only marginally improved (UNESCO,1981).

As can be seen from Table 5, although there were steady increases in enrolment ratios in all levels of education between 1965 and 1975, only about 60% of the population between the ages of 6 and 11 were enrolled in primary schools in the Third World. It was a rather disappointing figure comparing with the 94% in the developed countries.

4.4 Rise of Educational Costs

In fact, governments of developing nations have been pouring money into the educational sector since the 1960s and the growth rates of public expenditure in education are actually higher than the growth rates of GNP. The rise in public spending on individual students can be seen from Table 6. It is noted that between 1965 and 1977 the cost per student in education inreased five-fold.

With the continued rise in spending in education, we can see that there is not much room for further increase in the Third World since expenditure on education has already accounted for more than 4% of the GNP. According to an analysis by The Netherlands Economic Institute in 1975 (quoted from Buchanan,1975), "under moderate assumption the financial means of the developing countries, with the notable exception of Latin America, are insufficient to finance the estimated expenditures." From Table 7, we can see that Africa, even with a spending of 5% of the GNP on

Table 5: Enrolment Ratios in Developed and Developing Countries by Levels of Education, 1965-75 (in %)

	1st Level*			2nd Level+			3re Level+		
	'65	'70	'75	'65	'70	'75	'65	'70	'75
Developing Countries	54	58	62	19	22	26	2.2	3.2	4.4
Developed Countries	92	93	94	59	63	68	16.7	19.7	22.9

Note: * These were net enrolment ratios referring to % of population between the ages of 6 and 11 enrolled in primary school.

\+ These were gross enrolment ratios.

Source: UNESCO Yearbook, various years.

Table 6: Estimated Public Expenditures on Education for Developed and Developing Countries in various years

	Public Expenditure on Education (U.S.$, billion)				Average Annual Increase (65-77, in %)		Public Expenditure on Education as % of GNP				Public Expenditure on Education per Inhabitant (U.S.$)			
	'66	'70	'75	'77	A	B*	'65	'70	'75	'77	'65	'70	'75	'77
World Total	95.7	158.2	329.6	397.9	12.6	11.1	4.9	5.3	5.7	5.7	38	57	109	126
Developed Countries	87.8	145.8	292.4	348.2	12.2	10.8	5.1	5.6	6.0	6.0	87	139	267	314
Developing Countries	7.9	12.4	37.2	49.7	16.5	13.2	3.0	3.3	4.1	4.3	5	7	19	24

Note: * A: Public Expenditure on Education
B: Gross National Product
Source: Computed from UNESCO Statistical Yearbook, 1980.

Table 7: Estimated Total Educational Expenditures and Domestic Financial Means in The Third World, 1975

(in U.S.$ million)

	Total Educational Expenditures Assuming Primary Enrolment of			Domestic Financial Means		
	90%	75%	60%	5% GNP	4% GNP	3% GNP
Africa	3,400	3,150	2,890	2,430	1,950	1,460
Latin America	4,320	4,060	3,790	6,460	5,170	3,880
Asia*	5,320	5,400	4,990	5,060	4,040	3,030
India	5,550	5,230	4,920	2,930	2,340	1,760

Note: * Excluding China, Japan, and India.

Source: Buchanan, 1975.

education, which amounted to 2,430 million of U.S. dollars, still could not achieve a 60% enrolment in the primary level in 1975, which required a spending of U.S.$2,890 million. The problem thus becomes how to reduce the cost of education and increase the enrolment ratios.

4.5 Quality of Education

Even with the huge government spending on education, the quality of education in the Third World is much lower than the developed countries. The high repetition and dropout rates are only two examples of the poor quality of education. Of course, the quality of education is greatly influenced by the socio-economic environment in which teaching and learning take place. Thus, various factors such as the distance children have to walk to school, the living conditions of their families and their health and nutrition, the attitudes of their parents towards education and the relevancy of the curriculum to the needs of the children will affect the quality of education. Due to the lack of space, we can only examine the numerically assessable components of quality here.

4.5.1 Pupil-Teacher Ratio

Let us examine the pupil-teacher ratio first. From table 8 we can see that the ratios in the first and second levels of education in developing countries did not improve much between 1970 and 1977. Compared with the developed countries, a primary school teacher has to teach

Table 8: Pupil-Teacher Ratios in all Levels of Education in Developed and Developing Countries, various years

	First Level			Second Level			Third Level		
	'70	'75	'77	'70	'75	'77	'70	'75	'77
Developed Countries	23.2	21.1	20.5	16.6	15.8	15.7	13.7	13.9	13.7
Developing Countries	36.4	34.5	34.1	19.3	20.1	20.5	15.3	14.5	14.1

Source: computed from the UNESCO Yearbook, 1980.

approximately 14 more students (35 versus 21) in Africa or Asia. This may considerably lower the quality of education as the workload of teachers is so heavy and they cannot spend much time with individual students.

4.5.2 Teacher Training

The lack of adequate training for teachers in the Third World further exacerbates the problem. While teacher training is considered to be a high priority in education in the Third World, having all teachers fully trained is still a long way off. In general, primary school teachers in these countries receive ten years of schooling with two or three years of training. However, in the least developed countries, a considerable number of teachers may be found who are without any formal training in teaching and possess no more than primary education themselves. For example, in Indonesia, data around 1970 showed that only about 20% of the teachers could be regarded as fully qualified while about 25% were not qualified at all (Phillips,1975).

Besides the problems that we have just discussed, other equally important questions, such as poor access to education for rural children, the relationship between education and employment and ultimately the development goals of the developing countris should be addressed. Due to lack of time and space, we are not able to liscuss them here.

4.6 Summary

In this chapter we have discussed a few educational

problems in the Third World. The problems of adult illiteracy and the stagnation of the enrolment ratio are partly due to the lack of educational funds. What educators in the developing nations have to face is how to improve both the quality and quantity of education and develop an indigenous educational system relevant to the needs to their peoples. The following chapters will discuss the use of CAI in these countries, to see whether it can help to alleviate these problems.

CHAPTER 5

THE APPLICATIONS OF COMPUTERS IN EDUCATION IN THE THIRD WORLD

5.1 Introduction

Before we examine the cost-effectiveness of CAI in the Third World, it is imperative for us to have some knowledge of the state of the art of the application of computers in the educational field there. Unfortunately, as we have already mentioned in chapter three, not many research studies on this area have been identified by the writer. The few papers that appeared to be related to this topic failed to provide direct reference on how CAI was used in secondary schools. Although one paper (Ibrahim,1981) presented to the third IFIP World Conference was related to the application of CAI, its focus was on higher education.

5.2 Findings from the Questionnaires

In order to secure cost data on CAI hardware and software in the Third World market, the writer sent out 24 questionnaires to leading computer manufacturers in the U.S.A. to solicit their sales figures of computer software and hardware to the developing countries for educational purposes (see Appendices A ,B & C for the covering letter, questionnaire, and the list of computer manufacturers). Questions such as types of computers (large-scale, mini-or

micro-computer), price ranges, quantity, maintenance and traning costs both for hardware and software were asked.. These computer manufacturers were identified from the literature that the writer has surveyed and which are found to have business transactions with the Third World (Barquin,1975) and also because of their high rankings in computer sales in the U.S.A. (Million Dollar Directory,1983).

Of the 24 questionnaires sent out to the computer manufacturers in the U.S.A, only six were returned. Of these six, two were not willing to disclose any information while one had no transaction with any developing countries.

From this limited response, we cannot gather much information on the application of computers in the Third World. But one thing that is known is that microcomputers are being used in the developing countries, as can be seen from the sales figures of two computer firms. One company has sold 60 microcomputers to the Third World while the sale figure of another amounted up to U.S. $10 million (see appendix B). However, most of these computers are not purchased by high schools. Instead, universities and colleges have the highest demand for computers in the education sector. Also, they are not mainly used for instructional purposes. One respondent claimed that " while we sell computers equipment all through Africa and the Middle East, almost all of it is sold for administrative purposes, and up to this time, almost none for pure

educational purposes. Of course, administrative machines are made available to students for programs they are developing in Fortran, Basic or Cobol, but the fact remains that computers purely for education are still rare." This view was supported by another respondent who suggested that " most sales are really...to the business section of a college or to the electronics division...not really use to teach student through CAI."

The costs of computer hardware and software appeared to be unreliably high. One company stated that the price range of microcomputer was between $200K-$400K, which was substantially higher than the U.S. domestic price range (between $500-$2,900,see Table 13). Another computer company quoted a price range of between U.S. $1,500 -7,000, which seemed to be more reasonable. Maintenance and training were provided, but at a very high price (in one company, the cost of training for the use of software was U.S. $100k per site). If these price data are reliable, the total cost of the CAI system estimated in this study in the following chapter would have to be much higher.

5.3 Other Related Data

Besides the information obtained from the questionnaires, other sources of information provide us with some ideas of the extent to which computers are used in education in the Third World.

The United Nations conducted a survey on the applications of computers in the Third World in 1973. In the

study, the usage of computers on education and training was also surveyed. From Table 9 we can see that the actual number of computers which were used in the educational field was very small, and in six countries, no computer was actually used in education and training. Although in two countries the percentage of computers used in education was more than 20% , on the whole, the usage of computers in education was insignificant.

More recent data was provided by Loy et al (1977), who surveyed computer usages in five countries/ territories in Asia. From Table 10 we can see that only about 6% of all the computers found in the sites surveyed were used for educational purposes, which was very insignificant.

Indirect evidence showing that the use of computers in education in the Third World may be very limited comes from the overall limited number of computers available in these countries. According to the U.N. report (1973), the U.S.A. had a total number of 83,500 computers in the whole country in 1973, while Brazil,the most advanced country in the Third World, rated by the Computer Industry Development Potential (CIDP) developed by Barquin et al (1976), had only 1,219 computers, 1.5% of what the U.S.A. had in the same year. But Brazil's population was 52.5% of that of the U.S.A. in 1980 (Brazil had a population of 119 million while the U.S.A. had 226.5 million, The Europa Yearbook,1982). Botswana, one of the least developed countries in terms of CIDP level, had only

Table 9: Educational Computing in selected Developing Countries,1973

Country	Number of Computers Total	Education & Training	(%)
Bolivia	6	1	16.7
Brazil	1,219	110	9.0
C. Africa Rep.	3	0	0.0
Colombia	82	7	8.5
Cyprus	5	0	0.0
Fiji	6	0	0.0
Greece	175	7	4.0
Hungary	161	26	16.1
Iceland	17	1	5.9
Iraq	7	1	14.3
Jamica	34	3	8.8
Kuwait	17	1	5.9
Lebanon	29	0	0.0
Madagascar	24	1	4.2
Malaysia	28	1	3.6
Morocco	52	3	5.8
Nicaragua	14	0	0.0
Pakistan	19	2	10.5
Singapore	34	3	8.8
Sudan	4	1	25.0
Thailand	27	4	14.8
Turkey	82	8	9.8
Upper Volta	1	0	0.0
Yugoslavia	147	20	13.6
Zaire	19	4	44.4

Source: U.N.,1973

Table 10: Percentage of Computers used in University/Education in selected Asian Countries/Territories in 1976-77

Country/Territory	Number of Sites	%
Taiwan	13	12.2
Hong Kong	21	6.2
Malaysia	12	3.3
Philippines	29	2.2
Thailand	25	7.8
Total	100	5.9

Source: Loy et al,1977

one computer in 1973 in the whole country. There is probably a relationship between the level of the use of computers in a society and its application in education. As can be seen from the U.S.A., with such a high level of development in computing industry, nearly 3/5 of all secondary schools already used computer in instruction/administration in 1975 (Seidel,1980).

Actually, more up-to-date evidence on the level of computer usage in the Third World can be indirectly obtained from the U.S. exports of computers, parts and accessories to the developing countries. The U.S. export figures have significance in understanding the usage of computers in the Third World since the U.S. is one of the top computer exporters in the world. Between 1974 and 1980, as can be seen from Table 11, the developing countries only accounted for a very small percentage of computer sales of the U.S. In 1974, the Third World as a whole accounted for 12.2% of the U.S. export market and in 1980, it increased to 16.4%, representing an average annual increase of 0.7% only (U.S. Department of Commerce,1982). Of all the developing regions, Africa was the one which imported the least computers from the U.S.

The extent of CAI applications in education in a country is also related to the availability of computer personnel because they are crucial for the setting up of the CAI systems in schools. Even when the microcomputer is used as the delivery system, teachers have to be trained by

Table 11: U.S. Exports of Electronic Computers, Parts and Accessories to the Developing Countries,1974-80

		% of exports to			
Year	Total exports (in U.S. mil.)	Developing Countries	Latin Amer.	Africa	E. & S. Asia
1974	2,198	12.2	6.1	0.14	4.4
1975	2,228	15.6	7.0	0.22	3.9
1976	2,588	12.0	5.5	0.27	4.7
1977	3,264	12.1	5.9	0.25	4.3
1978	4,359	14.2	6.7	0.32	4.8
1979	5,671	15.4	7.8	0.25	5.3
1980	7,763	16.4	8.0	0.21	6.4

Source: U.S. Department of Commerce,1982.

computer professionals before they can manage the computing rooms or develop courseware. The shortage of computing personnel is always a problem in the Third World. According to the U.N. report (1973), there was a 20% to 30% shortage of trained personnel in centre managers and systems analysts in the developing countries. The shortage was even more serious in some countries, e.g. in Turkey, a manpower shortage of up to 83% was experienced in systems analysts and programmers.

This shortage of computer personnel is due to the inadequate training opportunities available in universities. In a recent survey of eight African countries conducted by Aban (1981), he found out that although some sort of computer courses were provided at university level, in all except one country the facilities available for education and training of computer professionals and scientists were grossly inadequate (Note 1). Aban also noted that of all the countries surveyed, not even one had any provision for education and training in computer science at secondary school level. If there is no computer science education in secondary school, it is hard to imagine that CAI would be used there, since usually CAI would be introduced after computer hardware are bought for the teaching of computer science or programming first, although the use of computers in school administration may also help to promote the use of CAI.

Computer education at the university level in Latin

America seems to be more developed than Africa. Of the 21 countries surveyed by Barquin in 1975, only one country had no computer course offered by the university. However, the shortage of computer professionals was also the greatest problem encountered by the governments in Latin America (Note 2).

5.4 Summary

In this chapter we have examined the available information on the application of computer in education in the Third World. From this piecemeal information we could not draw any definite conclusion with regard to the extent of the applications of computers in education in these developing nations. But the available evidence does provide support for our conjecture that the use of CAI is very limited in the Third World. Even if it is used, it would more likely be found in universities than in high schools.

CHAPTER 6

COST-EFFECTIVENESS OF A CAI SYSTEM

6.1 Introduction

In the last chapter we have discussed the applications of computers in education in the Third World and found that CAI is not being used extensively in secondary schools. Since no empirical studies were available, and the writer himself is unable to conduct field research , he can only take one developing country as a case study, estimate the cost components of the CAI system and evaluate its cost effectiveness, and compare it with the traditional method of instruction. Mexico was chosen as the country of study mainly because of two reasons. The first one is that Mexico is one of the more advanced countries among all the developing countries in terms of the CIDP level, an index developed by Barquin (1976) from a U.N. report on the application of computer technology in the Third World (1973) to show the level of computer usage of a country (see Appendix D for the CIDP index). It is therefore more likely that CAI would be adopted in this country since the infrastructure needed for the successful implementation of the CAI system would be available there. Secondly, cost-effectiveness of other educational technologies, namely, TV and radio were already conducted

there (Jamison et al,1978) and the result obtained from this study can be used for comparison in future.

In order to measure the cost-effectiveness of computer-assisted instruction in Mexico, we have to gather local cost data of the CAI system. In this study, except for the cost of the computer hardware, which is based on the U.S. domestic price, all other cost data come from the UNESCO Statistical Yearbook(1980, 1981). These yearbooks provide information on educational expenditures (including teachers' salaries) and pupil-teacher ratios of all levels of education in Mexico which are essential for the estimation of the total cost of the CAI system.

6.2 Limitations of The Study

The reader has to be reminded that the method used for the computation of the cost-effectiveness of the CAI in this study has many limitations. Since limited local data were obtained, this study at best can serve as an illustration of how the cost components of a CAI system can be estimated and its cost-effectiveness evaluated in a developing country. Thus, results obtained from this study should not be considered as conclusive, nor should any generalisation be attempted in other developing countries. Some of the limitations in the estimation of costs are as follows:

(1) The whole case study is hypothetical in the sense that all the cost components of the CAI system in Mexico were estimated costs. For example, the cost of the

computer hardware was based on the domestic U.S. market prices, not on its export prices to Mexico. Domestic and export prices of the same commodity may be greatly different due to the different tariff regulations, the size of the markets and the aggregate demand, foreign exchange differentials, and cost of shipment, etc. Thus the cost of the computer hardware may be over- or under-estimated.

(2) The cost data were drawn from different years and therefore may be incompatible. For hardware, they are 1983 figures, while the cost of courseware, which were calculated in terms of the teachers' salaries, were 1978 figures. When the cost feasibility of the CAI was evaluated by comparing it with the government spending per student, the 1978 figures were used. In this way the result may be a little bit distorted. Extrapolation is not attempted here because no real increases in teachers' salaries are predicted due to the huge inflation in the past few years in Mexico. Also, since the cost of CAI is calculated in terms of U.S. funds, the landslide devaluation of the peso in last year would also reduce the inflated educational expenditure (including teachers' salaries) back to the 1970s level.

(3) When we computed the cost of the courseware, we assumed that they were written by the teachers, which might not be a valid assumption in the Third World context simply because of the lack of expertise. However, if we assumed that this courseware was purchased from the

developed countries, no cost data could be obtained. This is another limitation on the cost computation.

6.3 Cost Components of a CAI System

6.3.1 The Difficulties in Measuring CAI Costs

The costs of CAI are difficult to measure. Although some of the cost components, e.g. equipment, hardware and courseware may be quantified, according to Kreasley (1977), because of the dynamic nature of the computing field where dramatic changes in technology can occur within a period of a few years, previously made cost estimates of CAI can be invalidated easily by new developments in hardware and software and, to a lesser extent , by instructional methodology.

Besides, some other cost components are difficult to estimate, e.g. the lease schedules and amortisation terms. Also, special attention has to be paid to local situational variables which are highly variable. When discussing the cost-effectiveness of CAI, Avner (1978) points out that it is situation-specific instead of product-specific. That is, no matter how many prestigious researchers conclude that the application of CAI is cost-effectiveness at a certain level of education for certain groups of students, it doesn't mean that CAI is cost-effectiveness in other implementations because even trival differences in accounting methols can be enough to make apparently identical situations liffecnt. This point is particularly important when we try to alopt a CAI

system in a developing nation. Prior feasibility studies have to be conducted and necessary modifications have to be considered. If not, it would be like the introduction of an 'open university model' to those countries where there was no reliable postal system or dependable TV transmission and reception (Gallegos,1982).

Bearing these points in mind, we must be very careful when we try to make any comparison in costs between CAI and the traditional method of instruction. Besides taking the work of others as reference, we have to gather detailed local cost data so that the results obtained can be more realistic and are more relevant to the local situation.

6.3.2 Cost Structure of a CAI System

Before going to the actual cost computation, let us discuss the general cost structure of a CAI system.

The cost components of a CAI system can be classified in various ways. One can classify them by functions, e.g. costs can be categorised into facilities, equipment, personnels, etc. One can also classify these costs in terms of fixed investment of recurrent costs. As a general framework for the computation of costs, which can be useful for different types of computing systems --large-scale, mini- or micro-computers, the former classification is used in this paper.

According to Kearsly (1977), the cost components of a CAI system may include the following:

(a) System Hardware

- cost of the CPU (Central Processing Unit)
- cost of the necessary peripherals, e.g. disk, tape storage, I/O devices, front end processors, etc.
- cost of student terminals

(This hardware can be rented or bought. If it is bought, we have to calculate the amortisation which will be discussed later)

(b) System Software

-cost of the purchase/rental of the operating system, course authoring languages, graphics or audio software, utility progaram,etc.

(c) Telecommunication Cost

-the transmission costs from the central computing system to the terminals via voice-grade telephone lines, digital data network, microwave, UHF TV, or satellites.

(d) Operating Costs

-salaries of computer operators,system analysts or programmers, system manager, computing room coordinator and teaching assistants.

(e) Courseware Development Costs

-the cost of the time of the instructor/ author's time spent learning to use the

system, the time spent in off-line planning of the courseware (Austin,1975), programming and debugging courses.

-the cost of producing any adjunct materials,e.g. audio tapes,slies,workbooks, etc.

-the cost of continued maintenance of this courseware.

Besides calculating all these costs, we also have to take the expected usage of the system courseware (i.e. the number of students expected to use the courses, and the number of places or institutions at which the system is expected to be used) into consideration. It is because we are less interested in the total cost of the CAI system than in the average cost, i.e. the cost per student contact hour or academic year. Obviously, if more students use the CAI system, the cost can be lowered.

When we estimate the costs of the CAI system, we also have to consider whether the hardware and software are purchased or rented. It they are purchased, they represent some sort of capital investment and they will last for a number of years. We then have to estimate their life spans and amortise these costs.

When we amortise these costs,two variables have to be taken into account. One is the lifetime of the equipment i.e. its depreciation rate. If the hardware lasts for n years, then only a fraction of its cost,i.e. 1/n of

its cost, should be charged each year. The second variable is the social discount rate, which represents an interest rate because there is a cost (interest charge) involved in having capital tied up in a project. In a CAI system, this cost is measured mainly by the potential rate of return to capital invested elsewhere in the economy. The following standard equation helps us to calculate the annualised costs of these CAI components (Jamison et al.,1978 p.32):

$$\text{annualised cost} = c \times (r(1+r)^n)/((1+r)^n - 1)$$

where c = the cost of the component

r = social discount rate

n = number of years that the CAI component lasts.

All in all, costing CAI involves many subtle judgements and sometimes a politically sensitive one. That is why one CAI expert points out that " polls of experts in CAI have consistently shown that the cost of CAI is considered the obstacle to its widespread acceptance."(Kearsley, 1977,p.101)

6.3.3 Cost Components of a CAI System in Mexico

6.3.3.1 Types of Computer Used

When considering cost components of a CAI system in the Third World, the first thing that we have to examine is what type of computer hardware is most appropriate. What we are looking for is a computing system which is not only the cheapest but at the same time can provide all the instructional modes that are required in the high school.

There are three types of computers which can deliver CAI, namely, the large-scale computer system,the minicomputer and the microcomputer, as we have already discussed. Of these three types of computers, research studies conducted in the U.S. all conclude that the large-scale computing system is the most expensive while the microcomputer is the least expensive one. A study carried out by Gleason in 1981 showed that a single terminal of the time-shared PLATO system operated by the Computer-Based Education research Laboratory at the University of Illinois and Control Data Corporation would cost more than U.S. $6,000. According to Gleason, it is only its access to a large and growing library of software that justified its existence (p.10). Although it is less expensive,the operating capacity of the minicomputer is limited. One school in Norfolk, Virginia bought a minicomputer in 1975 which could only handle a maximum of 32 terminals. When the school wanted to further expand its CAI in language arts curriculum, it could not afford to spend more than $100,000 to buy another minicomputer, which cost $3,125 per terminal. Instead, microcomputers were bought which could perform the same functions as the minicomputer (Gull,1980). No doubt, a stand alone microcomputer is the cheapest since its price, including the CPU, monitor, single disk drive or cassette tape only ranges from U.S. $500 to $2,900 in 1983 (Williams & Shrage,1983). As well as being cheap, the microcomputer can perform almost every function

that the other two types of computers can (Gleason,1981), even for conducting research and experiments, which was only possible in large-scale minicomputer-based laboratories in the past (Johnson,1982).

Not only the hardware costs of a large computing system are substantially higher than those of a microcomputer, the telecommuniation costs involved in the delivery of CAI has also to considered. One advantage of the large computing system is its capability of distributing educational computing services through its terminals located in schools scattered all over the country. This capability is useful to the Third World. For example, of the 15 million pople in Tanzania, which is a relatively large territory of comparable size to Egypt, only 6% of the population live in urban areas (Harris,1980). However, the telecommunication costs are very substantial. As the total dispersion of the population increases, and as the size of the user unit (in terms of the number of installation of computer terminals) decreases, communication costs become a larger and larger factor of the total operating costs (Butman,1975). Besides, in many developing countries, telephone lines may not be available even in the urban areas. The extension of this service from another city, or using other means of communication,e.g. satellites, may mean additional costs. Also, in some rural areas, the lack of supply of electricity to drive the terminals may mean another obstacle to using large-scale computing systems.

Besides telecommunication costs, the use of large scale computers or minicomputers may involve other costs, like the construction or renovation of a particular room to house these computers. According to Matvoich (1973), new facilities have to be constructed. Special wiring for the computer is needed and the installation of a separate humidifier to insure the proper control of humidity is also necessary. Air conditioning for the maintenance of proper environmental conditions, which is especially important in the developing countries which are usually located in the southern hemisphere, has also to be installed for the utilisation of the system. All these are add-on costs. According to one study (Levin & Woo,1980), the annualised costs for the construction and renovation of a room for installing a minicomputer accounted for 8.5% of the total annual cost (Note 3), which could not be considered to be negligible.

Apart from economic reasons, the microcomputer should be used in the Third World because of the factors of management and maintenance. To manage a large computer system or minicomputer, system analysts, centre managers or operation supervisors have to be employed to look after the system. However, for microcomputers, fewer computer professionals are needed since software and courseware can be bought from commercial firms or users groups. As for maintenance, microcomputers are all stand alone computers, and a breakdown of one will not affect the

delivery of the CAI course. But for the other two systems, maintenance is more difficult.

Finally, it is more likely that large-scale computer system and minicomputers may increase the inequality of education opportunities between urban and rural areas in the Third World than microcomputers. The reason is that these two types of computers are most efficient when serving a geographically compact population. That means, in the developing countries, they would tend to serve the larger cities. As urban-rural disparity in educational opportunitis is already a serious problem in the Third World (UNESCO,1980), if introduced into the urban areas only, CAI will aggravate this problem, without improving the quality of education in these countries as a whole. On the contrary, stand alone microcomputers may be used in rural areas where small electricity generators can be supplied (this problem will be further discussed in the next chapter).

Because of all these reasons, the writer concludes that the microcomputer is more appropriate to the Third World to deliver CAI. In this study it will be taken as the standard hardware of a Mexican high school, in order to minimise costs.

6.3.3.2 Cost Estimation--Total Cost

Based on the cost structure of the CAI system that we have previously discussed, the following cost components of a CAI system in a Mexican high school are estimated:

(a) Hardware

Since microcomputers are chosen as the delivery devices of CAI lessons, we have to decide what type of microcomputer we need and the amount. Table 12 shows the microcomputer requirements per instructional mode. From this table, we can see that if we want to deliver every mode of CAI instruction in the high school, the random access memory (RAM) capability of these microcomputers must at least be 32K bytes, and we also need the disk drive instead of cassette tape based drive. A recent price comparison of microcomputer, as can be seen from Table 13, shows that price of a 32K bytes computer with disk based ranges from U.S. $1,250 to 2,900, all with color monitor. If we use black (or green) and white monitor with tape cassette-based, the price can be lowered to $800. In view of the trend of decreasing prices, it is not unreasonable to take $1,250 as our price for one microcomputer which can well serve our instructional purposes. One limitation in this price estimate is that this price is the local price in the U.S. home market, but not export price and the cost of shipment is not included. The cost of shipment is not included in this estimate because the actual market price will be lowered if computers are purchased in bulk, which can offset the cost of delivery. According to the writer's personal experience and his communication with teachers teaching in Latin America, it is not uncommon that class enrolment will be up to 45 students. If CAI is used for

Table 12: Microcomputer Requirements

Per Instructional Type

	Drill & Practice	Tutorial	Problem Solving	Simulation
Memory (RAM)	4-8K	16-32K	8K	8-32K
Lower Case Characters		Y		Y
Cassette &/ or Disk	C	D	C	D
Graphics				Y
Printer		Y		
Floation Point Arithmetic			Y	
Files		Y		Y
Interface		Y		Y
No. of lines on Display	12	24	16	24

Note: Y=Yes C=Cassette D=Disk

Source: Nomeland, R., quoted from Thomas, D. 1981.

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Table 13 Comparison of the Features of Popular Classroom Microcomputers

	TAPE CASSETTE BASED				CARTRIDGE BASED			DISK BASED					
DISPLAY	VIC 20	PET 4032	COMMODORE 64	TRS 80 III	ATARI 400	ATARI 800	TEX INSTR 99/4A	ATARI 400	ATARI 800	TRS 80 III	APPLE 2+	COMMODORE 64	IBM PC
#of characters per line	22[1]	40[2]	40	64	40	40	28	40	40	64	40[2]	40	80
Upper/lower case	Yes	Yes[3]	Yes	Yes	Yes	Yes	No[4]	Yes	Yes	Yes	Extra $	Yes	Yes
Color available	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Graphics quality	Very Good	Good	Excel	Fair	Excel	Excel	Excel	Excel	Excel	Fair	Very Good	Excel	Excel
KEYBOARD													
Standard typewriter	Similar	No	Similar	Similar	No	Similar	No	No	Similar	Similar	No	Similar	Similar
Numeric keypad	No	Yes	No	Yes	No	No	No	No	No	Yes	Extra $	No	Yes
#of keys	66	74	66	65	61	61	41	61	61	65	52	66	83
CHARACTERISTICS													
ROM-maximum	5K	18K	20K	14K	10K	10K	32K	10K	10K	14K	24K	20K	40K
RAM-typical	5K	32K[5]	64K	16K	16K	16K	16K	16K	48K	16K	48K	64K	64K
RAM-maximum[6]	32K	32K	64K	48K	48K[7]	48K	48K	48K[7]	48K	48K	512+K[7]	64K	512K[7]
Disk capacity	NA	NA	NA	NA	NA	NA	NA	88K	88K	138K	140K	170K	160K
Can use regular TV	Yes	No[8]	Yes	No[8]	Yes	Yes	Yes	Yes	Yes	No[8]	Extra $	Yes	Extra $
More than one user per disk	NA	NA	NA	NA	NA	NA	NA	No	No	Yes[9]	Yes[10]	Yes[11]	No
Tape loading speed	41 cps	41 cps[12]	41 cps	50/150 cps[13]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Full-screen editing	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Extra $	Yes	Yes
Portability (#of pieces)[14]	3	2	3	2	2	2	2	3	3	1	3	3	3
BASIC included in price?	Yes	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	No
Expected to continue in production[15]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
PRICE[16,17]	$500[18]	$800	$950[18]	$850	$625[18]	$950[18]	$550[18]	$1200[18]	$1500[18]	1650[18]	$1750[18]	$1250[18]	$2900[18]

NOTES

[1] 40 col option available from another manufacturer
[2] 80 col available at extra cost
[3] Requires typing a POKE statement
[4] Two sizes of upper case letters, no true lower case.
[5] 16K PET recently discontinued
[6] In-chassis maximum
[7] Requires hardware from a different manufacturer
[8] Black (or green) and white monitor built in
[9] Requires additional hardware
[10] Presently requires hardware from a different manufacturer; Apple will introduce its own hardware shortly.
[11] Requires a more expensive disk drive
[12] Can be speeded up at additional cost
[13] User selectable
[14] CRT, keyboard, CPU, single cassette or single disk drive
[15] Based on industry rumors and publications
[16] Includes color monitor (when appropriate), typical RAM, and single disk drive or cassette (except cartridge units)
[17] Approximate mail order price per unit assuming order of three units
[18] With color monitor
[19] With 48K RAM

Source: Williams & Shrage. p.8

mainline instead of adjunct instruction, 45 microcomputers have to be purchased, which amount to U.S. $56,250.

Besides these microcomputers, at least one printer should be available in the computing room for the printing of hard copies. According to a recent price survey carried out by the editors of Creative Computing (1983), there are 25 types of printers which are under U.S. $1,000. Thus, it is reasonable to take $1,000 as the cost of a printer in Mexico.

(b) System Software and Courseware

The microcomputers that are purchased have already built-in operating systems. If the BASIC programming language is used and no utility programs (e.g. for word processing or record keeping) are required, no extra cost for software has to be included. As for courseware, they can either be bought or developed locally. The latter method is preferred because they are more appropriate to the local conditions. Initially we shall assume that two full time teachers have to be devoted for the development of these courseware. Cost of training will not be included since this is usually provided free of charge by the computer manufacturers. The cost of courseware is therefore calculated in terms of teachers' salaries. In our case, the salaries of two Mexican teachers amount to U.S. $3,752 (in 1978, UNESCO,1981,see Note 4).

(c) Telecommunication Costs

No telecommunication cost will be included

since all the microcomputers are stand alone computers.

(d) Operating Costs

With regard to operating costs, one coordinator is needed in the computing room for time-tabling and also serving as a teaching assistant. This coordinator should have some knowledge of the microcomputer and should be able to give advice to students and teachers. He should also provide assistance in the development of the courseware. Thus the salary of this coordinator should be more or less the same as a high school teacher, which amounts to U.S.$1,876 per year(UNESCO,1981). Together with the two full time CAI instructors/authors , a team of three teachers should be sufficient to look after the CAI system and dvelop the courseware.

The operating cost also includes the use of facilities and buildings. Construction of a computing room is too costly and non-essential. Lack of funds is one reason and bureaucratic practices in many developing countries may only delay the construction of the room indefinitely. Thus it is more practical to house these microcomputers in a classroom or a special room which is already available in the school. One class may have to share a classroom with the others so that a room is made available to house these computers, which means no additional cost.

The cost of maintenance of the hardware and software should also be included in the estimation of costs.

A service contract with the wholesaler/manufacturer can usually be secured at a 10-15% of the prices of the products (per year). In view of the backwardness of the transportation network and the lack of service personnel in the developing countries, 15% of the prices of the microcomputers and the printer, which amount to U.S.$8,785 is estimated to be the cost of maintenance of the hardware per year.

As for the maintenance of the courseware, it will take the form of updating the CAI programs in every two or three years. Since two teachers have already been employed as courseware developer, no cost of mantaining courseware is included in the present cost estimation.

(e) Total Cost

With all these costs added up together , the initial capital investment will amount to U.S.$71,663, which is summarised in Table 14.

6.3.3.3 Annual Cost of the CAI System

However, the total cost that we have just computed does not represent the annualised cost of the CAI system. As we have mentioned before, the hardware, software and courseware can be used for more than one year, and their costs should therefore be amortised. The annualised cost of the hardware is therefore depends on its initial cost, C, its lifetime, n, and the social discount rate, r. Table 15 shows the annualised cost of the computer hardware when its lifetime is between one and five years and the social

Table 14: Summary of the Estimated Total Cost of a CAI System in Mexico

Cost component	U.S. $
(a) Hardware	
Cost of 45 microcomputers (at $1,250 each)	56,250
Cost of 1 printer	1,000
(b) Software & Courseware	
Salaries of 2 teachers	3,752
(c) Operating Costs	
Maintenance (15% of $56,250)	8,785
Salary of 1 coordinator	1,876
Total	71,663

Table 15: Annualised Cost of Computer Hardware of Computer Hardware of a CAI System with different Interest Rates(r) and Years(n)

Year	Annual Cost(in U.S. $) with interest rates of 10%	15%	20%
1	57,250	57,250	57,250
2	32,987	35,215	37,473
3	23,021	25,116	27,178
4	18,061	20,053	22,115
5	15,114	17,061	19,143
6	13,145	15,128	17,216
7	11,760	13,761	15,884
8	10,731	12,814	14,924
9	9,941	11,998	14,205
10	9,317	11,409	13,660

Note: The initial cost (C) of the computer hardware is U.S.$ 57,250

discount rate is between 10%-15%. When the value of C, i.e., the initial cost of the hardware is U.S.$.57,250 and assuming that the lifetime of the microcomputer and printer is five year (Note 5) and a social discount rate of 15%, we have the following:

$$\text{annualised cost} = C \times [\, r(1+r)^n \,]/[\, (1+r)^n - 1]$$

$$= 57{,}250 \times [0.15(1.15)^5\,]/[\,(1.15)^5 - 1]$$

This is equal to U.S. $17,061 per year.

For the annualised cost of the courseware, it is reasonable to expect that it can operate for at least two years before updating is required. Thus, the cost of the courseware development,i.e. the total salaries of the teacher/authors should be halved, which amounts to U.S. $1,876 per year.

The total annualised cost of this CAI system is summarised in the following table, Table 16, with different interest rates taken into consideration.

As can be seen from Table 16, the annualised cost of the hypothetical CAI system ranges from U.S. $27,651 to $31,680. If we take 15% as the interest rate, which is rather reasonable in view of the present and forseenable world economic situation (at present, the interest rate is only about 10%), the cost of our system is U.S. $29,598 per year.

The total annual cost of the CAI system is less useful than the average cost per student per year, if we want to compare it with the cost of traditional method of

Table 16: Total Estimated Annualised Cost of a CAI System in a Mexican High School, in different interest rates

Component	Annual Cost (in U.S.$) with interest rates of 10%	15%	20%
(a) Hardware			
45 microcomputers and 1 printer	15,114	17,061	19,143
(b) Courseware	1,876	1,876	1,876
(c) Operating Costs			
Coordinator	1,876	1,876	1,876
Maintenance	8,785	8,785	8,785
($) Total	27,651	29,598	31,680

instruction. If we assume that there are eight CAI sessions per day that each lasts for 40 minutes and occurs five days per week, there are altogther 40 CAI sessions per week. With 45 terminals, there are totally 1,800 terminal/sessions that can be used by students in the high school. With an enrolment of 900 students, each student can then receive two CAI lessons per week, either of the same, or different subjects. In this case the CAI cost per student per year will be U.S.$29,598/900, which is U.S. $32.89,or $33 per year for two sessions per week.

We can also compute the CAI cost per student per period (40 minutes). Assuming that there are 180 school days per year, and 8 CAI periods per day, with 45 terminals available in the school, there are altogether 64,800 (180 X 8 X 45) terminal/periods per year. The cost per student per contact period amounts to U.S.$0.46 ($29,598/64,800), which is substantially higher than instructional computing delivered in the developed countries. As we have mentioned before, one study (Doerr,1979) reported that the cost was only $0.18 per student contact hour. The reason for a higher cost in the developing countries may be due to the higher spending on the development of courseware. In developed countries,especially in the U.S.A.or Canada, the courseware is commercially available or may be obtained cheaply from some non-profit making user groups.

6.3.3.4. Cost Effectiveness of the CAI System

If we compare the cost that we have just computed

with the cost of the traditional method of instruction in Mexico, we can see whether CAI is cost-effective. The cost of traditional instruction is based on the spending on teacher's salary per student. The average salary of a high school teacher was U.S.$1,876 in 1978 and the student-teacher ratio in that year was 17 (UNESCO,1981). Assuming that there are 180 school days, and each teacher has to teach 6 periods per day, then they have to teach 180 X 6 X 17 students-periods per year. Thus the cost of instruction per student per period amounts to U.S. $0.10 ($18,76/(180 X 6 X 17)), which is very much cheaper than the cost of CAI,which is $0.46 per student-period. However, we have to note that the cost of traditioanal instruction is underestimated since teachers' salaries should have been increased in the past five years. But even with a real increase in salary of 10% per year, which is highly unlikely due to the inflation in the Mexican economy in the past few years, the cost will only be increased to U.S. $0.16.

The CAI cost would be smaller if we take it as a mainline instruction because we can deduct the cost of traditional instruction from the CAI period. Thus, the CAI cost per period per student would be reduced to U.S. $0.36 ($0.46-$0.1). Also, if we take the reduction of learning time into consideration, a time reduction factor can be included in the calculation of the CAI cost. Time saving of CAI of between 20-40% were documented in many studies, as

have been reviewed in chapter three. A moderate time reduction factor of 0.7 is taken in our study, meaning that students receiving CAI can reduce their learning time by 30%. Thus the new CAI cost becomes $0.25 ($0.36 X 0.7), still 2.5 times more expensive than the traditional method of instruction, which is not considered to be cost-effective at all.

6.3.3.5 Cost Feasibility of the CAI System

The preceding cost analysis takes CAI as a mainline instruction and then compares it with the traditional instruction. But CAI can also be taken as an adjunct instruction, providing remedial or enrichment experiences to the students. In that case, the cost of CAI will be considered as an add-on cost. We have therefore to consider whether it is feasible for a Mexican high school to spend U.S.$33 per student per year on CAI. In order to examine whether it is cost-feasible, one method is to examine the annual government spending (capital and current) in education per student. The most recent data that we can get is 1978, and although it is possible for us to estimate the spending on education in 1983 by means of projection, the figure obtained will not be too reliable since there was huge inflation and landslide devaluation of the peso in the last year. Also, there is no reason to expect a great increase in government spending on education in the past few years. Thus we stick to the 1978 fiugures.

From Table 17 we can see that only U.S. $11.12 were

Table 17: Government Spendings on Students in Mexico,1978

	Spendings (in peso,'000)	No. of Students	Spendings/ Student (U.S.$)
Total	99,336,655	18,226,505	239.40
Capital	4,613,454	18,226,505	11.12
Current	69,759,301	18,226,505	168.10
Primary level	25,581,129	13,614,115	82.53
Secondary level	16,055,020	3,914,251	180.15
Tertiary level	17,584,452	698,138	1,106.24

Source: UNESCO Yearbook,1981, Tables 4.1,3.11,3.7,3.4 and Appendix C

spent as capital investment per student in Mexico in 1978. Even if all the money were spent in the implementation of the CAI, it was just short of about 22 dollars per student. Of the $180.15 spent on a high school student as current expenditure, only about 12% (estimated from 1977 figures, see UNESCO,1980) were allocated for direct teaching materials, which amounted to about $22 while $110 were spent as teacher's salary. Only if all the current expenditure on instructional materials, in addition to the capital expenditure were spent on the CAI system would its cost be covered.

We can see that the add-on cost of U.S.$33 per student is so high that if no additional funds are injected into the educational sector, either by the government or by some international organisations, CAI appears to be unattractive to Mexican schools, at least economically. However, CAI can still be introduced at the cost of providing less of some other school resources to the students. Actually, some writers advocated that with the introduction of CAI, the student-teacher ratios can be increased (e.g. see Butman,1975). Jamison (1976) has suggested a formula to calculate the opportunity cost of CAI, i.e. the cost (not in monetary term) that we have to pay in order to introduce CAI.For example, the increase of the class size. From the following equation, we can calculate the new class size of our hypothetical Mexican school if CAI is introduced.

$$\frac{T}{S} = \frac{T + C(S+A)}{S + A}$$

Where T= total spending on teachers' salaries for a class of 45 students i.e. $110 X 45

S= the class size before CAI is introduced i.e. 45

C= cost/student/year of CAI i.e. $33

A= the number of additional students in the class that required to finance the CAI

From this equation, we can calculate that the additional students required to finance the introduction of the CAI for a class is about 20. That means, the class size has to be increased from 45 to 65, a very substantial increase and obviously impossible to achieve.

Another way is either to cut down the number of teachers or their salaries. Since $33 has to be spent per student per year on CAI and about $110 has to be spent on teacher's salary per student ,we can see that either the salary or the number of teachers in the school has to be reduced by about 1/3, if CAI is to be introduced. It is surely impossible, form both educational and political points of view.

6.4 Summary

In this chapter we have discussed the cost structure and components of a CAI system. Based on this

framework, the cost of a CAI system in a Mexican high school was calculated. Its cost-effectiveness and feasibility were then computed. It was found out that in this hypothetical case the use of the microcomputer in education could not reduce educational costs since it was not cost-effective and was not feasible for the educational system .

CHAPTER 7

THE APPROPRIATENESS OF CAI IN DEVELOPING COUNTRIES

7.1 Introduction

In the preceding chapter the cost effectiveness of CAI in a developing country was estimated. Although it was only a hypothetical case, it gave us some idea of how expensive CAI in a developing country could be. Unless there is drastic reduction in the cost of computer hardware and software , which is quite possible because of the competition among computer manufacturers and the rapid expansion of market into the developing regions, CAI won't be extensively employed in the Third World. In this chapter the writer wants to argue that even if CAI is used in future in the developing nations, due to economic or political reasons, it may not be appropriate or effective and it may create more problems than it can solve. We would like to discuss these problems one by one.

7.2 Economic Considerations

CAI may not be appropriate to the Third World because one should be aware that as a new technology, particularly when it is considered as a product (i.e. a particular item or set of equipment) instead of a process (i.e. the systematic approach to learning (Harper,1979)), it is developed in the developed countries

and is then transferred to the devloping countries. Like the transfer of technology in general , as discussed by many economists (e.g. Lall & Streeten,1977; Moxon,1979), the problem of appropriateness arises. The reason is that "technology is not a neutral entity, but reflects the culture, the conditions and aspirations for which it is conceived and for which it is intended. It is not just a mode of production, but embodies and reflects the economic, social, political, cultural and cognitive modes of society in which it is produced." (Ventura,1981,p.60)

The inappropriateness of the transfer of technology from the developed to the developing nations can be explained by the difference of economic conditions experienced in the two regions. When we talk about economic conditions, we mean that the factors endowment i.e., the availability of labour and capital that countries have are different. Although the factors of production (i.e. labour, capital ,land) can be changed theoretically to suit different economic conditions, in reality, only economically efficient production methods will be employed in production. What is economically efficient depends on the ruling factor prices in which the production method is being developed. As the real wages of labour in the developed countries are becoming higher and higher, the factor price of capital becomes relatively cheaper. Thus the products and the process of production tend to be capital intensive, with higher rates of capital expenditure per man. It is

also labour saving, with lower rates of labour per unit of output. In this way the cost of production is minimised. But in the developing countries the economic condition is just the opposite, where the supply of labour is abundant and capital is scarce. When capital intensive products and production methods are transferred to the developing countries, the use of resources is inefficient and the production cost is therefore higher (Lai,1981).

Although the preceding discussion refers mainly to industries, it is also relevant to a great extent to education. The huge difference in capital resources between the developed and developing countries can be seen from Table 18. From this table we can see that the public expenditure on education per inhabitant in the developed countries was nearly 30 times more than the developing countries in 1978. It is no wonder why capital intensive technologies can be used in the developed nations. Computer (and CAI) is a very capital intensive technology which can be economically advantageous to the educational system in developed regions simply because the salaries of the teachers there are very high. As seen from Table 19, which compares the salaries of high school teachers in selected developing and developed countries in 1978, the salaries of teachers in the latter were very much high than the former. In terms of expenditure on teacher's salary per student, the developed countries also were much higher than the developing countris. For example, W. Germany was about 22

Table 18: Public Expenditure on Education Per Inhabitant in Selected Regions,1978

Region	Spending (in U.S.$)
Developed Countries(Total)	366
North America	622
Developing Countries(Total)	26
Africa (excluding Arab States)	21
Asia (excluding Arab States)	52
Latin America	60

Source: UNESCO Yearbook,1981

Table 19: Average Salary of High School Teachers and Expenditure on Teacher per Student in Selected Countries,1978 (in U.S.$)

	Average Salary	Average Expenditure on Teacher per Student
Developed Countris		
France	16,918	1,220
Japan	16,235	960
W. Germany (1977)	36,094	2,427
Developing Countries		
Mexico	1,876	110
Botswana	4,735	281
Venezuela (1975)	4,998	298

Source: Computed from UNESCO Yearbook,1981.

times as much as Mexico. With such a high labour cost, it is very important that their time be properly utilised and the use of capital intensive technology would be relatively cheaper.

In the developing countries, however, because the salaries of teachers are not as high as developed countries, and because of the lack of capital (and foreign exchange), capital-intensive technology should not be employed there. With limited funds in the educational sector, the question is where they should be channelled. In my view, in view of the present economic conditions of the Third World, funds should be used in the most effective way so that most children can be properly educated. It seems to me that the emphasis now should be placed more on the quantity instead of quality of education. Thus, other educational technologies such as ETV and radio, which are more effective in mass education, rather than individualised instruction may be promoted. Indeed, various successful cases have been documented, as mentioned before.

7.3 Cultural Considerations

The new educational technology may not be appropriate in the Third World (in the sense that it is less effective) also because of the difference in culture. As suggested by Pena (1983), an educator in Latin America, one of the reasons why education technologies which tried to penetrate in Latin America have failed has been the technologist's lack of awareness of the impact of technology

on any culture. It is argued that any new educational technology cannot be successfully implemented if its development is not a response to the indigenous people's own problem, but rather as the result of the expansion movement of other people. As for CAI, it basically emphasizes individualised learning. Also , no matter what CAI mode is used, it is mainly visually-based. However, even up to now, teacher is still the centre of the teaching-learning process in the Third World (Gallgos,1982). Students usually lack the cultural background and motivation for learning without an instructor under an open time frame. Also, the primary mode of transmitting knowledge in these countries has historcially been an oral one. Even the textbook is considered to be secondary (or, students simply can't afford to have textbooks). Thus, the transmission of knowledge by any other means, like CAI, may be considered as a lesser or limited worth in some societies (Gallegos,1982). With the cultural difference in mind, CAI which is effective in the developed countries may be less effective in the Third World. Even if CAI is to be used in the Third World, it may have to be modified and designed to solve The Third World problems. It has to act within the social and cultural environment of The Third World and its economic possibilities (Pena,1983).

7.4 Educational Inequality

So far when we talked about the transfer of CAI to the Third World, we referred only to its benefits or limit-

ations to the whole country, without discussing the question of who will really benefit fron this transfer. We should note that when CAI is transferred to the Third World, not every school board will be able to purchase it. Instead, only the richer schools, which are usually located in the larger cities will be able to afford to buy these computer hardware and software. The disparity of resources between urban and rural areas in the Third World is documented. For example, according to one study (Cummings & Lemke,1973), the most urbanised states in South Brazil containing 36% of the population spent 59% of the educational budget and the major state of the region, San Paulo, had an educational per capita expenditure 7 times as great as the states of the Northeast, which contained 22% of the population. The urban schools can set up a CAI system because they probably have the expertise, mainly due to the higher qualifications of their teachers, or they are located near to the universities. But the students who live in rural areas, are the last ones to benefited from this technology. In this way the rural-urban disparity in educational quality will further be enlarged. However, even if rural kids do receive CAI and improve their achievement, they have no greater opportunity for employment than before. The reason is that the employment opportunity in the rural areas is simply limited. By using CAI, the education system may be internally more efficient in teaching, say, e.g. Mathematics. But externally it is not sucessful at all

(McAnany,1978). Thus, with the transfer of computer technology to the educational sector in the Third World, there might be some marginal and isolated changes while the basic educational structure will not be changed at all.

7.5 Summary

In this chapter the appropriateness of using CAI in the Third World was discussed and evaluated. It was argued that the new educational technology might not be appropriate for the developing countries due to economic and cultural reasons. It might also increase the disparity in educational opportunities between urban and rural areas. Unless the cost of CAI is further reduced so that it is less costly (economic consideration) and equally effective (cultural consideration), compared to traditional instruction , then its application in secondary education in the Third World should not be encouraged.

CHAPTER 8

SUMMARY,CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary

The purpose of this project has been to examine whether the use of CAI is cost-effective in the developing countries. If it is indeed cost-effective, relative to the traditional method of instruction, then it may help to reduce educational costs which is one of the factors hindering the expansion of enrolment in primary and secondary education.

In order to examine the cost-effectiveness of CAI in education in the Third World, we have first of all to examine whether CAI as a method of instruction is effective or not. From the review of literature we found that the use of CAI was effective in the developed countries where students receiving CAI had a higher achievement and could reduce the time for learning. With regard to costs, the result was not conclusive because these studies were very situation-specific. In some cases the CAI were less expensive while in others they were not.

Due to the lack of field research findings of the application of computers in education in the Third World, questionnaires were sent to major computer manufacturers in the U.S.A. to solicit information of their sales of

computer hardware and software to the Third World. A hypothetical case was used to calculate the cost of setting up microcomputer-based CAI system in a Mexican high school. Cost of the computer hardware was based on 1983 prices found in the U.S. domestic market while the cost of courseware was based on the salaries of the Mexican high school teachers in 1978. The cost of the CAI system per student per period was then compared with the cost of traditional method of instruction. The total annual CAI cost per student was then compared with the government annual spending per student, so as to evaluate its cost feasibility. The limitations of the study was also discussed.

Besides examining the cost-effectiveness of a CAI system in the Third World, this project also discussed the appropriateness of using this technology in these countries, since the socio-economic situations between developed and developing countries are so different. The economic and cultural factors were taken into consideration while whether CAI would have adverse effect on educational opportunity and quality of education in the rural areas was also discussed.

8.2 Conclusions

From this study the following conclusions can be drawn:

(1) The cost of a CAI system, using microcomputer as the delivery device is the least expensive of the three

possible systems since the computer hardware is the least expensive and other costs,e.g. telecommunication costs and the cost of other peripheral facilities are not included.

(2) The cost of a CAI system in a developing country may be more expensive than a similar system in the developed country due to the cost in the development of the courseware. In the developed countries, much courseware is commercially available. But in the Third World, due to the difference in culture and language, local courseware will have to be developed.

(3) The CAI system may not be cost-effective in the Third World if it is taken as a mainline instruction. In our hypothetical case, the CAI cost per student per period was U.S. $ 0.46, while the cost for traditional method of instruction was only U.S. $0.10 per student per period.

(4) Taking the reduction of learning time into consideration, which may not be capitalised by the system since even with the shortened instructional time, the educational system may not be able to translate that into a decreased time in schooling for students in a manner which will offset the added cost of CAI, the CAI was still 2.5 times more expensive than the traditional method of instruction.

(5) Taken as an adjunct instruction, the CAI would become an add-on cost. With a government spending (capital expenditure) of only U.S. $11.12 per student in Mexico in 1978, which may not be substantially increased even in 1983, a total annual CAI cost of U.S.$33 per student appeared to

be too expensive for a developing country. This CAI cost would not be too heavy for the governments of the developed countries to bear since their spending per student is much greater. This CAI cost is currently not feasible for the developing countries.

(6) The CAI as a technology may not be appropriate for the developing countries. In the economic sense computer is a capital-intensive technology developed in countries which are abundant in the supply of capital. The developing countries, on the contrary, are capital scarce while labour abundant. In the developed countries, the salaries of teachers are much higher than the developing countries (e.g. the salary of a high school teacher in West Germany was 22 times more than a Mexican teacher in 1978) which may justify the use of computers in scondary schools. Even if funds are available, they should be channelled to those technologies which are less capital-intensive.

(7) Due to the difference of cultures, CAI may be less effective in the Third World because students are not used to individualised and visual learning.

(8) CAI may increase the disparity of educational opportunities and quality between urban and rural areas since only those rich shcool districts are able to purchase computers overseas. Even if rural schools have a chance to use CAI, and therefore improve the quality of education there, students may not have a better chance for social mobility since better jobs are only available in the cities.

Better educated students in rural areas may then migrate to the cities, thus aggravating the problem of rural-urban migration.

(9) Finally, CAI may not be the best method to improve the quantity of education in the Third World even if it may reduce educational costs because its emphasis is on individualisation. Instead, technologies which focus on mass education, like radio or TV may be better methods, in view of the urgent need for the elimination of illiteracy in the developing countries.

8.3 Recommendations

After conducting the study, the following recommendations are made:

(1) There is an urgent need for educators to conduct more empirical field studies in the developing countries on the applications of computer in education in general, and the application of CAI in particular so that more information can be available to policy makers as regard to whether CAI should be used.

(2) A framework for the calculation of cost of the CAI system in the Third World context should be worked out so that the cost-effectiveness of CAI can be measured.

(3) The appropriateness of CAI in the developing countries also deserves more attention. It may be more important than simply considering the costs.

(4) The impact of CAI on the culture of the Third World societies should be examined since even if CAI can

solve some of the educational problems, it may create more problems in other areas.

(5) Finally, the computer should not be considered as the panacea of all educational problems in the Third World. What we have discussed shows that at best it can only alleviate a few educational problems. The complex and intertwining educational problems in the Third World may only be understood from a socio-economic perspective and solutions to these problems may only be found there.

REFERENCE NOTES

1. The countries surveyed were: Kenya, Nigeria, Senegal, Tanzania, Uganda, Malawi and Ghana. In Uganda, no informatics education and training facilities were available while facilities in Nigeria, Ghana and Kenya were far more better than the other countries.

2. However, the reader has to be reminded that computer manufacturers accounted for the larger share of education at the operation, programming and system design and analysis levels in Latin America (see Barquin,1975).

3. The annualised cost of construction was U.S. $8,524 while the total cost was U.S. $100,000.

4. The average salary of a high school teacher was obtained by dividing the total teachers' emoluments by the total number of teachers in the second level of education, which actually included teachers who were teaching in the teachers' training college. The salary was then changed to U.S. dollars by multiplying the exchange rate, which was 0.04392 (1 peso to 0.04392 dollar).

5. The depreciation rate of a microcomputer was obtained by personal communication with the instructor of the computing room of the Faculty of Education,Queen's University.

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* These studies are most useful to the study of the cost-effectiveness of CAI.

APPENDIX A

Covering Letter

FACULTY OF EDUCATION
DUNCAN McARTHUR HALL

Queen's University
Kingston, Canada
K7L 3N6

May 3,1983.

Dear Sir,

Re: Request for Information on Computer Application in Education in Developing Countries

I am a graduate student in the Faculty of Education of Queen's University and am now doing research on the cost-effectiveness of using computers in education (computer-assisted and managed instructions) in developing countries.

I would be most grateful if you could provide me general information on the sales of computer hardware and software (large, mini or micro-computers) of your esteemed company to developing countries for educational purposes during the past few years.

Enclosed please find a questionnaire and it would be greatly appreciated if you could complete and return it to me at your earliest convenience. The data obtained will only be used for research purposes and your help will be duly acknowledged.

Thanks for your kind attention and I am looking forward to hearing from you soon.

Yours faithfully,

(Kwok-Wing Lai)

APPENDIX B

Questionnaire on the Sales of Computers to Developing Countries for Educational Purposes

Name of the firm: A

Date: May 19, 1983

Please complete Part I first. Return the completed questionnaire not later than June 10, 1983 to Mr. Kwok-Wing Lai, Rm. A031, Duncan McArthur Hall, Faculty of Education, Queen's University, Kingston, Ontario, Canada K7L 3N6. Thank you for your co-operation.

Part I

1. Have you ever sold any computer hardware to any developing countries?
(YES) / NO

If your answer is YES, please answer questions in Part II.

2. Have you ever sold any computer software to any developing countries ?
(YES) / NO

If your answer is YES, please answer questions in Part III.

* Even if your answer for both questions are NO, it is important to my research that this questionnaire be returned to me. *

Part II : Computer Hardware

	Large Computing System	Mini-Computer	Micro-Computer
1. Quantity of computer hardware sold to developing countries for educational purposes (up to '83)?			Approx. 60
2. Price range? (in U.S.$)			$200k-$400k
3. Is maintenance provided? (YES/NO)			yes
4. At what price?			Approx. $40k per location

	Large Computing System	Mini-Computer	Micro-Computer
5. Is training provided? (YES/NO)			yes
6. Cost of training.			Approx. $100k per site
7. Is software provided? (YES/NO)			yes
8. List, in decreasing order, the institutions in the educational sector which have the highest demand of computer hardware. (e.g. ministry of education, university, high schools, etc.)	1.	1.	1. Armed Forces
	2.	2.	2. Industry Vocational
	3.	3.	3. Schools
9. List, in decreasing order, the three developing countries which have the highest demand of computer hardware for educational purposes. (up to 1983)	1. Kindom of Saudi Arabia		
	2. United Arab Emirates		
	3. Indonesia		

Part III: Computer Software

	Large Computing System	Mini-Computer	Micro-Computer
1. Quantity of educational software packages sold to developing countries.			Approx. 60
2. Price range (in U.S. $)			$50k-$75k
3. Quantity of software packages leased to developing countries.	NOT APPLICABLE		
4. Price range of monthly lease.		"	
5. Is training provided? (YES/NO)			yes
6. Cost of training.			$100k per site
7. Is maintenance provided? (YES/NO)			no
8. At what price?	NOT APPLICABLE		

List the major problems encountered in selling computer hardware and/or software to developing countries.

1. Lack of Technical Ability

2. Language

3. Fighting against preconceived ideas

Other comments/details:

In interperting this questionnaire it is important that you know that (our company) customers are typically the various branches of the Armed Forces whose personnel need maintenance training. To satisfy this requirement, Educational Computer Corporation markets a standard system, consisting of a microprocessor based computer system, and a random access projection system. This general configuration is then customized by developing a unique simulation which is used for teaching the various subsystems of an aircraft, a tank, etc.

Using this training device, trainees can be taught logical/safe electrical, electronic, hydraulic, etc., troubleshooting procedures in a classroom environment. This preserves the actual equipment, e.g. a tank or an aircraft for full operational use, plus reduces on the job training (OJT) time.

We are enclosing some brochures that may give you some insight into our product line and at the same time assist you in your research.

GOOD LUCK!

Thank you!
* END *

Questionnaire on the Sales of Computers to Developing Countries for Educational Purposes

Name of the firm: B
Date: 5/11/83

Please complete Part I first. Return the completed questionnaire not later than June 10, 1983 to Mr. Kwok-Wing Lai, Rm. A031, Duncan McArthur Hall, Faculty of Education. Queen's University, Kingston, Ontario, Canada K7L 3N6. Thank you for your co-operation.

Part I

1. Have you ever sold any computer hardware to any developing countries?
(YES) / NO

If your answer is YES, please answer questions in Part II.

2. Have you ever sold any computer software to any developing countries ?
(YES) / NO

If your answer is YES, please answer questions in Part III.

* Even if your answer for both questions are NO, it is important to my research that this questionnaire be returned to me. *

Part II : Computer Hardware

	Large Computing System	Mini-Computer	Micro-Computer
1. Quantity of computer hardware sold to developing countries for educational purposes (up to '83)?			$10 Million US.
2. Price range? (in U.S.$)			500 - 7000
3. Is maintenance provided? (YES/NO)			YES
4. At what price?			LOCAL

	Large Computing System	Mini-Computer	Micro-Computer
5. Is training provided? (YES/NO)			NO
6. Cost of training.			—
7. Is software provided? (YES/NO)			YES
8. List, in decreasing order, the institutions in the educational sector which have the highest demand of computer hardware. (e.g. ministry of education, university, high schools, etc.)	1.	1.	1. UNIV.
	2.	2.	2. COLLEGES
	3.	3.	3. VOC. SCHOOLS
9. List, in decreasing order, the three developing countries which have the highest demand of computer hardware for educational purposes. (up to 1983)	1. COLOMBIA		
	2. AUSTRALIA		
	3. MALAYSIA		

Part III: Computer Software

	Large Computing System	Mini-Computer	Micro-Computer
1. Quantity of educational software packages sold to developing countries.			$2 MILLION
2. Price range (in U.S. $)			30 - 800
3. Quantity of software packages leased to developing countries.			—
4. Price range of monthly lease.			—
5. Is training provided? (YES/NO)			NO
6. Cost of training.			—
7. Is maintenance provided? (YES/NO)			YES
8. At what price?			N/C

List, the major problems encountered in selling computer hardware and/or software to developing countries.

1. LACK OF HARD CURRENCY
2. IMPORTATION BARRIERS/ HIGH DUTY / BUY LOCAL EFFORTS
3. LOW COMPUTER LITERACY AMONG DECISION MAKERS

Other comments/details:

Your questionnaire is not really tailored for gathering data on CO. performance. Most sales are really to small companys, the business section of a college or to the electronics division. Not really used to teach students through CAI.
Local distributors handle servis and installation, price & service contract is up to them.

Thank you!
* END *

BEST COPY AVAILABLE

Questionnaire on the Sales of Computers to Developing Countries for Educational Purposes

Name of the firm: C

Date: 3 JUNE 1983

Please complete Part I first. Return the completed questionnaire not later than June 10, 1983 to Mr. Kwok-Wing Lai, Rm. A031, Duncan McArthur Hall, Faculty of Education. Queen's University, Kingston, Ontario, Canada K7L 3N6. Thank you for your co-operation.

Part I

1. Have you ever sold any computer hardware to any developing countries?
(YES) / NO

If your answer is YES, please answer questions in Part II.

2. Have you ever sold any computer software to any developing countries ?
(YES) / NO

If your answer is YES, please answer questions in Part III.

* Even if your answer for both questions are NO, it is important to my research that this questionnaire be returned to me. *

Part II : Computer Hardware

	Large Computing System	Mini-Computer	Micro-Computer
1. Quantity of computer hardware sold to developing countries for educational purposes (up to '83)?	6-8 systems	3-4	—
2. Price range? (in U.S.$)	up to $250K	$100K	—
3. Is maintenance provided? (YES/NO)	Yes	yes	
4. At what price?	7-8% of list price of hdwe	same	

	Large Computing System	Mini-Computer	Micro-Computer
5. Is training provided? (YES/NO)	Yes	Yes	-
6. Cost of training.	varies - difficult to put a price		-
7. Is software provided? (YES/NO)	Yes	Yes	
8. List, in decreasing order, the institutions in the educational sector which have the highest demand of computer hardware. (e.g. ministry of education, university, high schools, etc.)	1. ~~Min of Ed~~ Univ 2. Min of Ed 3. N.S.	1. Some 2. 3.	1. - 2. - 3. -
9. List, in decreasing order, the three developing countries which have the highest demand of computer hardware for educational purposes. (up to 1983)	1. Egypt 2. Zimbabwe 3. Tanzania		

Part III: Computer Software

See remarks.

	Large Computing System	Mini-Computer	Micro-Computer
1. Quantity of educational software packages sold to developing countries.			
2. Price range (in U.S. $)			
3. Quantity of software packages leased to developing countries.			
4. Price range of monthly lease.			
5. Is training provided? (YES/NO)			
6. Cost of training.			
7. Is maintenance provided? (YES/NO)			
8. At what price?			

List the major problems encountered in selling computer hardware and/or software to developing countries.

1. _____

2. _____

3. _____

Other comments/details.

While we sell computer equipment all through Africa and the Middle East, almost all of it is sold for administrative purposes and, up to this time, almost none for pure educational purposes. Of course, administrative machines are made available to students for programs they are developing in Fortran, Basic or COBOL, but the fact remains that computers purely for education are still rare.

Thank you!
* END *

Appendix C: List of Computer Manufacturers

1. A P F Electronics Inc.
2. Apple Computer Inc.
3. Atari,Inc.
4. Bell & Howell Co.
5. Burroughs Corporation
6. Commodore Business Machines Inc.
7. Computer Automation Corporation
8. Control Data Corporation
9. Datapoint Corporation
10. Digital Equipment Corporation
11. Education Computer Corportion
12. Health/Zenith Corporation
13. Hewlett-Packard Corporation
14. Honeywell Inc.
15. International Business Machines Inc.
16. National Semicondutor Corporation
17. N C R Corporation
18. Olivetti Corporation of America
19. Radio Shack Inc.
20. Sinclair Research Limited
21. Sperry Univac Corporation
22. Texas Instruments Inc.
23. Wang Laboratories Inc.
24. Xerox Corporations

APPENDIX D

Categorisation of selected developing countries by CIDP level

Initial
Afghanistan, Bangladesh, Bhutan, Botswana, Burma, Burundi, Cambodia, Cameroon, Central African Republic, Dahomey, Ethiopia, Haiti, Laos, Lesotho, Liberia, Malawi, Mali, Nepal, Niger, Rwanda, Senegal, Somalia, Southern Yemen, Yogo, Tonga, Uganda, Upper Volta, Weatern Samca, Yemen

Initial to Basic
Albania, Algeria, Bahamas, Barbados, Bolivoa, Congo, Cyprus, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Gabon, Gambia, Ghana, Guatemala, Guinea, Guyana, Honduras, Indonesia, Iraq, Ivory Coast, Jamaica, Jordan, Kenya, Libya, Malagasy, Mauritania, Morocco, Nicaragua, Nigeria, Pakistan, Paraguay, Saudi Arabia, Sierra Ieone, Sri Lanka, Sudan, Swaziland, Syria, Tanzania, Thailand, Trinidad, Tunisia, Zaire, Zambia

Basic
Chile, Colombia, Cuba, Iran, Lebanon, Malaysia, Panama, Peru, Philippines, Republic of Korea, Singapore, Taiwan, Turkey, Uruguay

Basic to Operational
Bulgaria, Greece, Hong Kong, Hungary, Puerto Rico, Rumania, Venezuela

Operational
Argentina, India, Mexico

Operational to Advanced
Brazil, Israel

Source : "Model for progress in developing nations"
Datamation Vol.5, no.3, September 1976
International Supplement, p190-A - 190-H
R.C. Barquin, T. Nishimura, K.A. Whitney, [6]

Levels of computer activity

LEVEL	CHARACTERISTICS
Initial	There are no operational computers in the country. A few nationals have had contact with computing. The only local sources of information are computer salesmen.
Basic	There is some understanding of computers in government (and private) decision centres. A few computer installations are to be found. There are some nationals involved in computer operations. There is some education and training in computer technology in the country. Computers are used in basic government operations.
Operational	There is extensive understanding of computers in government (and private) decision centres. Among the numerous computer installations there are some very large machines. There are centres for education and training in computer technology and some are of excellent quality. They offer degree programmes in computer or information science. There is design and production of software and some manufacture of hardware. Computers are affecting many disciplines, particularly science, engineering and medicine.
Advanced	Most government and administrative work is carried out by computers. There are well established professional activities and national meetings on computers. There is a complete range of quality education and training programmes. The number of computers, of all sizes, is increasing rapidly. Time-sharing, teleprocessing and remote job entry are common. There is design and production of both hardware and software. Many technologies have been changed or are in the course of being changed. New applications of computers are found regularly. There is strong participation in and contribution to international activities.

Source : The Application of Computer Technology for Development
UN, Department of Economic and Social Affairs,
New York, 1971, [1]